

Springer Series in Geomechanics & Geoengineering

Stéphane Bonelli
Cristian Dascalu
François Nicot *Editors*

Advances in Bifurcation and Degradation in Geomaterials

Proceedings of the 9th International
Workshop on Bifurcation
and Degradation in Geomaterials

 Springer

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Preface

Geomaterials exhibit intriguing mechanical behaviours with a variety of failure modes ranging from diffuse to localized deformations depending on stress, density, microstructure and loading conditions. For instance, diffuse failure in a soil mass under constant gravity-driven load occurs with a sudden phase change triggering catastrophic large fluid-like movements. Another remarkable example of related phenomena is degradation arising from cyclic loading, ageing, weathering, chemical attack and capillary effects, among others. Today, it is well-recognized that the various manifestations alluded to in the above are a result of material and/or geometric instabilities that can be studied within the framework of micromechanics and bifurcation theory.

Interests in localization and related instabilities in the field of geomechanics date back to the early 1980s when the first International Workshop on Localization of Soils was organized in Karlsruhe, Germany, February 1988. This aroused so much enthusiasm and interest in the fundamental aspects of bifurcation theory for soils that the second workshop followed right after in Gdansk, Poland, September 1989. The topic was then extended to rock mechanics at the third international workshop in Aussois, France, September, 1993. Interests grew steadily and the scope was expanded to instabilities and degradations in geomaterials at the fourth, fifth, sixth, seventh and eighth workshops that were held in Gifu, Japan, September 1997; Perth, Australia, November 1999; Minnesota, USA, June 2002; Crete, Greece, June 2005; and Lake Louise, Canada, May 2008.

The ninth international workshop continued the central theme of bifurcations and degradations in geomaterials, with further extensions into geo-environmental applications. The workshop venue, Porquerolles Island in Southern France, was an idyllic setting for discussing the science and engineering in the natural beauty of the Mediterranean region.

IWBDG 2011 was attended by 90 participants representing 12 countries, with 55 presentations given over three days. In particular, this meeting fostered the participation of young researchers, including doctoral students and postdoctoral fellows. As a major co-sponsor, CATERPILLAR Inc., USA provided generous

financial support to IWBDG 2011, similar to the previous Workshop in Lake Louise. Additional support was provided by (in alphabetical order), CEMAGREF, CNRS, EdF, GeophyConsult, Provence Alpes-Cotes d'Azur Province, Université Joseph Fourier.

This proceeding contains 46 peer reviewed full papers that are a sampling of presentations given at IWBDG 2011, capturing the state-of-the-art in the specialized field of geomechanics and contemporary approaches to solving the central issue of failure.

We would like to dedicate this Workshop to Professor Ioannis Vardoulakis who tragically passed away in September, 2009. He played an eminent role as one of the founders of this series of workshops. His substantial contributions, both technical and as a mentor to young researchers were pivotal to the success of the IWBDG series. We trust this is a fitting tribute to an outstanding man and scientist.

The members of the Advisory Board,

Ronaldo Borja
Félix Darve
Jacques Desrues
Hans Muhlhaus
Richard Wan

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Instability and Bifurcation for Inelastic Geomaterials

R. Chambon

Abstract During the past issues of the workshop on localization and bifurcation in soils and rocks, the two words instability and bifurcation are used by many participants and induce many strong discussions. I am convinced that most of these discussions are only semantic ones and that indeed this is due to two main things. In the best case discussion is triggered by the fact that different people have different definitions of these words, in the worst case some people have no explicit definition of the word used. We try in this paper once more to put forward the intrinsic difficulties of true instability and bifurcation studies for geomaterials and see how numerical tools can finally help us.

Keywords Instability • Bifurcation • Numerical computation • Controllability • Inelasticity

1 Introduction

Difficulty about distinguishing stability from bifurcation is in our opinion a consequence of the fact that mainly for elastic situations, loss of uniqueness is related with the so called exchange of stability which means that as soon as several solutions are available, the “old” one becomes unstable whereas the new ones are stable (this is typical for elastic buckling for instance). Consequently, in this case, it is sufficient to study loss of uniqueness to deduce loss of stability. Unfortunately geomaterials behave mostly as plastic materials. This means that cohesion and/or friction sliding is a main feature of their behavior, inducing energy dissipation independently of the

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