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Activity of the technical committee on the mechanics of granular materials – TC 13

Activité de la commission technique N° 13 sur la mécanique des matériaux granulaires

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ABSTRACT: The technical committee on the mechanics of granular materials (called TC-13) has been working since 1995 to promote co-operation and exchange information in the field of mechanics of granular materials. The main target is to encourage researches which can be applied to the fundamental subjects on the particulate mechanics such as micro-mechanical constitutive modeling of materials and explanation of micro-mechanism of the progressive failure. With such scope in mind, TC-13 organized the workshop at Hamburg, and is also planning to publish an introductory textbook on the mechanics of granular materials.

1 INTRODUCTION

The main objectives of TC-13 to be accomplished are; 1) to promote co-operation and exchange of information about mechanics of granular materials; 2) to encourage researches on the relevance of the particulate mechanics as applied in constitutive modeling and studies of the phenomena of progressive failure in granular materials with emphasis on practical applications; and 3) to organize, if appropriate, a Specialty Conference on the Recent Developments of Mechanics of Granular materials.

To accomplish these objectives, the committee was organized in 1994 by the following members:

Chairman:	Prof. M. Oda (Japan)
Secretary:	Dr. K. Iwashita (Japan)
Honorary Member:	Prof. M. Satake (Japan)
Core member:	Prof. C. S. Chang (USA)
	Prof. H. Matsuoka (Japan)
	Prof. F. Molenkamp (Netherlands)
	Prof. L. Rothenburg (Canada)
	Prof. C. Thornton (UK)
Members:	Prof. B. Cambou (France)
	Prof. Yao-Chung Chen (China)
	Prof. E. Dembicki (Poland)
	Eng. F. Federico (Italy)
	Eng. M. Hamoudi (Syria)
	Mr. J. De Jaeger (Belgium)
	Prof. I. I. Kandaurov (Russia)
	Prof. P.V. Lade (USA)
	Prof. J. Lanier (France)
	Prof. S. Nordal (Norway)
	Prof. T. Ramamurthy (India)
	Prof. P. Scharle (Hungary)
	Prof. J. S. Steenfelt (Denmark)

To support the activity of TC-13, the Japanese working committee was also organized in 1995 under the financial support by the Japanese Geotechnical Society. The committee members are: Prof. M. Oda (Chairman, Saitama University); Dr. K. Iwashita (Secretary, Saitama University); Dr. H. Hashimoto (Kyushu University); Dr. S. Iai (Port and Harbour Research Institute); Prof. Y. Kishino (Tohoku University); Prof. H. Matsuoka (Nagoya Institute of Technology); Dr. K. Miura (Hokkaido University); Prof. F. Oka (Gifu University); Prof. M. Satake (Tohoku-gakuin University); Dr. H. Sakaguchi (Kobe University); Dr. S. Sawada (Kyoto University); Prof. T. Tamura (Kyoto University); Dr. Y. Tobita (Tohoku-gakuin University). The working committee proposed two main targets under

support by TC-13; 1) to organize a workshop in Hamburg in 1997, and 2) to publish an introductory textbook on the mechanics of granular materials.

2 WORKSHOP IN HAMBURG

The workshop was held on 10th September 1997 at Congress Centrum Hamburg, Germany. About 20 ISSMFE members participated in a discussion at the workshop. The meeting was very successful in exchanging ideas among the participants. The presenters and the topics are:

Program: Part 1: Chairman M. Satake (Tohoku-gakuin University)

- 1) M. Oda and K. Iwashita (Saitama University):
Particle rotation and couple stress in the development of shear band of granular media.
- 2) H.G.B. Allersma (Delft University of Technology):
Optical measurement of stress and strain in granular material.
- 3) Y. Kishino (Tohoku University):
Application of granular element method.
- 4) C. Thornton (Aston University):
Mechanics and physics of granular media.

Part 2: Chairman M. Oda (Saitama University)

- 5) F. Oka (Gifu University):
Non-local constitutive models for geomaterials.
- 6) J. Lanier, D. Daudon and X. Thibault (Universite Joseph Fourier Grenoble):
Comparison of numerical and experimental results on 2-D granular material
- 7) M. Satake and Y. Tobita (Tohoku-gakuin University):
Fabric changes in pre and post liquefaction.
- 8) General discussion and final remarks by C. Thornton

3 PUBLICATION OF INTRODUCTORY TEXTBOOK

Over the past 30 years, the mechanics of granular materials has matured and a variety of excellent papers have been published in widely disseminated journals. The main objectives of the introductory textbook are, therefore, to produce a compilation of present knowledge in readily usable form and to make it easy for graduate students and young soil engineers to understand the essence. The book will consist of state-of-the-art reports written by about 35 internationally recognized authorities, and will cover the whole range of interest for soil

engineers in about 400 pages. The book, which will be published by Balkema in 1998, is arranged to provide readers with a primary reference source to a particular topic of granular soils. The contents and the authors are:

Title: Introduction to Mechanics of Granular Materials
Editors-in-Chief: M. Oda and K. Iwashita

Chapter 0. Preface (M.Oda)

Chapter 1. Fundamentals of Granular Mechanics

Editors: M. Satake, C.S. Chang, and Y. Tobita

1 Scope of this Chapter (M. Satake, C.S. Chang and Y. Tobita)

1.1 Geometrical Representation of Granular Assemblies

1.1.1 Voronoi-tessellation for granular assemblies (K. Bagi)

1.1.2 Graph representation (M. Satake)

1.2 Discrete Mechanics (M. Satake)

1.2.1 Formulation of discrete mechanics

1.2.2 Correspondence between discrete and continuum mechanical quantities

1.3 Stress, Strain, and Fabrics

1.3.1 Strain (K. Bagi)

1.3.2 Stress (K. Bagi)

1.3.3 Particles rotation and couple stress (M. Oda and H.B. Mühlhaus)

1.2.4 Fabric tensor (M. Oda and Y. Tobita)

1.4 From Micro Behavior to Macro (averaged) Behavior

1.4.1 Fundamental concepts in homogenization process (B. Cambou)

1.4.2 Micromechanical modeling for stress-strain relationship of granular materials (C.S. Chang)

1.5 Frictional Behavior and SMP

1.5.1 Friction based deformation and strength behavior (Y. Tobita)

1.5.2 Strength and deformation behavior based on SMP (H. Matsuoka)

1.6 Energy Principle in Granular Material

1.6.1 Microscopic dynamics and kinematics (M. Hori)

1.6.2 Energy principle of particle and assembly (N. Okada)

Chapter 2. Continuum Theory of Granular Materials

Editors: F. Oka, F. Molenkamp and T. Tamura

2.1 Introduction (F. Oka)

2.2 Constitutive Theories for Granular Materials

2.2.1 Elasticity theory (F. Oka and H.B Mühlhaus)

1) Cosserat theory

2) Strain gradient-dependent theory

2.2.2 Plastic theory

1) Flow theory (F. Molenkamp)

2) Double shearing theory (F. Molenkamp)

3) Cosserat theory (H.B. Mühlhaus)

4) Strain gradient-dependent theory (H.B. Mühlhaus)

2.2.3 Viscoplastic theory (F. Oka)

2.2.4 Rigid plastic theory (T. Tamura)

2.3 Instability and Bifurcation (T. Tamura, F. Oka and A. Asaoka)

2.3.1 Instability and bifurcation in boundary value problem

2.3.2 Instability and liquefaction of granular materials (F. Molenkamp)

2.3.3 Computations of strain localization (T. Tamura)

Chapter 3. Discrete Element Approaches

Editors: Y. Kishino and C. Thornton

3.1 Introduction (Y. Kishino)

3.2 Simulation using Discrete Elements

3.2.1 Distinct element method (Y. Kishino)

3.2.2 Granular element method (Y. Kishino)

3.2.3 Generalized models in discrete element approaches (C. Thornton)

3.3 Recent Applications of Distinct Element Approaches

3.3.1 Shearing mechanism in granular materials

(S. Yamamoto and H. Matsuoka)

3.3.2 Incremental behavior of granular material (J.P. Bardet)

3.3.3 On analysis of shear band in granular materials

(K. Iwashita and M. Oda)

3.3.4 Liquefaction analysis of granular materials (H. Nakase)

3.3.5 Three dimensional behavior of granular materials

(C. Thornton)

3.3.6 Eigen value analysis of granular materials (Y. Kishino)

3.4 Future Development in Discrete Element Analysis

(C. Thornton)

Chapter 4. New Findings from Experimental Studies

Editors: M. Oda and T. Ramamurthy

4.1 Introduction (M. Oda)

4.2 Fabric of Granular Materials and Its Development during Shear Deformation

4.2.1 Measurement of fabric elements (M. Oda)

4.2.2 Evolution of fabric during shear deformation and related topics (M. Oda)

4.2.3 An experimental study of the fabric evolution in granular materials using two-dimensional assembly (J. Lanier and F. Calvetti)

4.3 Recent Developments in Experimental Methodology

4.3.1 Non-invasive measurement of fabric of particle packing by NMR (M. Nakagawa, R.A. Waggoner and E. Fukushima)

4.3.2 Visualization of fabric by laser-aided tomography (K. Konagai)

4.3.3 Visualization of shear bands by X-ray tomography (J. Desrues)

4.3.4 Optical analysis of stress and strain in photoelastic assemblies (H.C.B. Allersma)

4.3.5 Use of acoustic emission to detect yield point (Y. Tanaka)

4.4 Recent Studies in Laboratories

4.4.1 Internal friction angle of granular soils (M. Oda)

4.4.2 Some fundamental problems related to soil plasticity (M. Oda)

4.4.3 Recent laboratory studies1: shear band development (M. Oda and T. Yoshida)

4.4.4 Recent laboratory studies2: stress-strain at small strain (F. Tatsuoka)

4.5 Liquefaction (K. Miura and S. Iai)

Chapter 5. Rapid Flow of Granular Materials

5.1 Theoretical Foundations

5.2 Numerical Simulation

5.3 Laboratory Studies on Flow of Granular Materials

4 CONCLUDING REMARKS

The main targets of TC-13 can be said to be to some extent accomplished. However, there is still a big gap between the theoretical field and the practical soil engineering. The committee members heartily hope that the introductory textbook can contribute toward filling up such a gap.