

Advanced Structured Materials

Holm Altenbach
Tetsuya Matsuda
Dai Okumura *Editors*

From Creep Damage Mechanics to Homogenization Methods

A Liber Amicorum to celebrate the
birthday of Nobutada Ohno

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ISSN 1869-8433
Advanced Structured Materials
ISBN 978-3-319-19439-4
DOI 10.1007/978-3-319-19440-0

ISSN 1869-8441 (electronic)
ISBN 978-3-319-19440-0 (eBook)

Library of Congress Control Number: 2015939823

Springer Cham Heidelberg New York Dordrecht London

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Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media
(www.springer.com)

Advanced Structured Materials

Volume 64

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Preface



Professor Nobutada Ohno is one of the leading Japanese researchers in solid mechanics and has a worldwide reputation because of his great impact on several research topics. This volume of the Advanced Structured Materials Series has been published to celebrate his 65th birthday, and to express sincere respect and gratitude for his significant achievements and longtime contributions to solid mechanics. Many active researchers in his fields have contributed to this memorial volume, some of them are close to Prof. Ohno, and have also contributed to his published studies. The contents of this book are not limited to one field.

Professor Ohno's research fields have been extensive, as seen in the book title "From Creep Damage Mechanics to Homogenization Methods," which will be referred to later in this Preface. We hope that the readers enjoy the variety of the contents of this volume.

Professor Ohno was born in 1950 in Ichinomiya, near Nagoya, and spent his early years there. After graduating from high school, he entered the Department of Mechanical Engineering in Nagoya University, and graduated with top honors in 1973. He then majored in solid mechanics in the graduate course, and received his Ph.D. from the university in 1979. He began his career as an Assistant Professor at Nagoya University before moving to the Toyohashi University of Technology in 1980, where he spent about 8 years. During this time, he spent a year at Harvard University in 1982 as a visiting scholar, and collaborated with Prof. John Hutchinson. In 1988, he returned to Nagoya University as an Associate Professor, and he has been a full Professor there since 1994.

In his academic career, Prof. Ohno has received many awards. He has received international awards such as the K. Washizu Medal (2001) and Khan International Award (2009), and a special issue was published in his honor in the International Journal of Plasticity in 2011. He has also received almost all of the major awards of the Japan Society of Mechanical Engineers (JSME). He has been awarded the

JSME Medal for Outstanding Paper thrice (1977, 1991, 2004), Materials and Mechanics Achievement Award (2004), Computational Mechanics Achievement Award (2006), Computational Mechanics Award (2010), Materials and Mechanics Award (2013), etc. He has been a fellow of JSME since 2002. The Japan Society of Materials Science (JSMS) has also awarded him the JSMS Award for Scientific Papers (1998), JSMS Award for Academic Contribution (2005), etc. He also received the JACM Award from the Japan Association for Computational Mechanics in 2010.

His many awards and honors clearly show his outstanding academic achievements. However, it is difficult to explain what his research field is because his research has been quite wide-ranging, as is often the case with distinguished researchers. We will take this opportunity to summarize his main achievements, although we cannot cover all of his research because of space limitations. The summary below will briefly describe his extensive research, and will help the readers understand the meaning of the title of this book. His papers mentioned in this summary are listed at the end of Preface.

1. Continuum theory of anisotropic creep damage

Nobutada Ohno investigated continuum modeling of anisotropic creep damage during his doctoral studies under the supervision of Prof. Sumio Murakami. As a result, a continuum theory was developed in which a second order tensor was shown to be an internal variable to represent the anisotropic damage caused by net area reductions in tertiary creep (Murakami and Ohno 1981). This study is highly evaluated as one of the pioneering works on anisotropic damage modeling, and has been cited in many papers and books.

2. Non-hardening region in cyclic plasticity

Ohno (1982, 1986) postulated that isotropic hardening does not evolve within a plastic strain region after a load reversal, and represented the plastic strain region, referred to as the non-hardening region, by generalizing Chaboche's memory surface. This postulation was used to represent work-hardening stagnation for accurate springback analysis by Yoshida and Uemori in 2002. Professor Ohno thus contributed to the well-known Yoshida-Uemori model, which has been available in LS-DYNA and PAM-STAMP since 2007.

3. Kinematic hardening model for ratcheting

The nonlinear kinematic hardening model of Armstrong and Frederick is well known, but has the drawback of overpredicting ratcheting and cyclic stress relaxation. Ohno and Wang (1993a) improved the dynamic recovery term in the Armstrong-Frederick model. The developed model, called the Ohno-Wang model, is highly rated and has been used by many researchers to simulate ratcheting and cyclic stress relaxation. The papers of Ohno and Wang (1993a, b) and Abdel-Karim and Ohno (2000) have been cited many times.

4. Homogenization methods for nonlinear time-dependent composites

Ohno and co-workers extended the computational homogenization method of periodic composites to include nonlinear time-dependent behavior such as creep and viscoplasticity (Wu and Ohno 1999; Ohno et al. 2000). The method was

further extended in the presence of point-symmetric internal structures (Ohno et al. 2001). The extended methods have been verified by simulating the experiments of long fiber-reinforced laminates and plain-woven laminates (Matsuda et al. 2003, 2007, 2014). Recently, the homogenized viscoplastic behavior of pore-pressurized, anisotropic open-porous solids has been studied (Ohno et al. 2012, 2014).

5. Homogenization analysis of cellular material instability

By developing an updated Lagrangian-type homogenization method based on two scales of periodic structures, the elastic and elastoplastic buckling behavior of hexagonal honeycombs subjected to in-plane biaxial compression were analyzed to elucidate the complex buckling modes observed in experiments (Ohno et al. 2002; Okumura et al. 2002, 2004). These studies have been frequently cited, and have been presented in about twenty invited lectures, including five plenary lectures, at conferences. The method has been applied to other cellular materials (e.g., Ohno et al. 2004; Takahashi et al. 2010).

6. Strain gradient plasticity based on the self-energy of GNDs

Considering the self-energy of geometrically necessary dislocations (GNDs), Ohno and Okumura (2007) provided an explicit physical basis for strain gradient plasticity theories, and analyzed model crystal grains to derive a closed-form evaluation of initial yield stress. They showed that the self-energy of GNDs explains well the grain-size dependence of initial yield stress in the submicron to several-micron range of grain sizes. This study is highly regarded, and has been presented in about ten invited lectures, including one plenary lecture, at conferences.

7. Implementation of cyclic (visco)plastic models in FEMs

Implicit stress integration algorithms were developed to implement cyclic (visco)plastic models, including the Ohno-Wang model, using user subroutines in commercial finite element programs (Kobayashi and Ohno 2002; Kobayashi et al. 2003; Akamatsu et al. 2008; Ohno et al. 2013). The subroutine programs developed for cyclic thermomechanical analysis have been used by about ten companies in Japan. Recently, the programs have been integrated into a new version, OLMATS (Ohno Lab. Material Model Software).

As well as performing the above-mentioned research, Prof. Ohno has also been actively involved with scientific journals. He has served as an editorial board member of the *International Journal of Plasticity* (1991 to present), *Computer Modeling in Engineering and Sciences* (2004–2010), *International Journal of Solids and Structures* (2005 to present), *Acta Mechanica Solida Sinica* (2009 to present), and *Bulletin of the JSME* (2014 to present). He has also served as the editor-in-chief of the *Journal of Solid Mechanics and Materials Engineering* (2006–2007), an associate editor of the *Materials Science Research International* (1997–1999) and *JSME International Journal, Series A* (2000–2003), a guest co-editor and guest editor of the *International Journal of Plasticity* (2000, 2008), and a guest editor of the *International Journal of Mechanical Sciences* (2008).

Moreover, he has played a number of leading roles in academic societies and conference organizations. He has held important positions in academic societies, such as the chair of the JSME Materials and Mechanics Division (2002), chair of the JSME Computational Mechanics Division (2008), executive board member of the JSMS (1996–1997, 2000–2001, 2005–2006), executive board member of the JSME (2013–2014), and vice president of the JSME (2014). He has also made substantial contributions to international and domestic conferences by serving as, for example, the co-chair of the 5th IUTAM Symposium on Creep in Structures (2000), chair of the 8th Asia-Pacific Symposium on Engineering Plasticity and Its Applications (2006), and chair of the 56th JSMS Annual Meeting (2007). All of these conferences took place at Nagoya University, and were very successful owing to his strong leadership.

Professor Nobutada Ohno has had a significant impact on solid mechanics because of his original and unique point of view. His work has spread from academic to industrial fields: your laptop or car may contain proof of his achievements. In addition, he has served in academic societies for decades. His about 20 Ph.D. students have moved into academia and industry. He has hosted several foreign researchers for short- and long-term stays at Nagoya University. All of these contributions have given us great respect for him, and we regard him as an ideal researcher. At the same time, he is a man of heart and humor. He is a husband, father, and grandfather, loves watching movies, and is a fan of the Chunichi Dragons-Nagoya's professional baseball team.

We are grateful to Prof. Ohno for his seminal and longtime contributions to solid mechanics, and believe that he will continue to have an impact in research.

Last but not least, we gratefully acknowledge Dr. Christoph Baumann and Benjamin Feuchter (Springer Publisher) for support of the book project.

Magdeburg
Tsukuba
Nagoya
September 2015

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Selected Papers of the Main Achievements of Professor Nobutada Ohno

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