

Advances in Engineering Structures, Mechanics & Construction

SOLID MECHANICS AND ITS APPLICATIONS

Volume 140

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Department of Civil Engineering
University of Waterloo
Waterloo, Ontario, Canada N2L 3G1

Aims and Scope of the Series

The fundamental questions arising in mechanics are: *Why?*, *How?*, and *How much?*
The aim of this series is to provide lucid accounts written by authoritative researchers giving vision and insight in answering these questions on the subject of mechanics as it relates to solids.

The scope of the series covers the entire spectrum of solid mechanics. Thus it includes the foundation of mechanics; variational formulations; computational mechanics; statics, kinematics and dynamics of rigid and elastic bodies; vibrations of solids and structures; dynamical systems and chaos; the theories of elasticity, plasticity and viscoelasticity; composite materials; rods, beams, shells and membranes; structural control and stability; soils, rocks and geomechanics; fracture; tribology; experimental mechanics; biomechanics and machine design.

The median level of presentation is the first year graduate student. Some texts are monographs defining the current state of the field; others are accessible to final year undergraduates; but essentially the emphasis is on readability and clarity.

For a list of related mechanics titles, see final pages.

Advances in Engineering Structures, Mechanics & Construction

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Edited by

M. PANDEY

University of Waterloo, Ontario, Canada

WEI-CHAU XIE

University of Waterloo, Ontario, Canada

and

LEI XU

University of Waterloo, Ontario, Canada

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*This volume of research papers is dedicated by the
authors to*

Professor Donald Edward Grierson

*on the occasion of his retirement from the
University of Waterloo*

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PREFACE

This volume is the proceedings of the *International Conference on Advances in Engineering Structures, Mechanics & Construction*, convened at the University of Waterloo on May 14–17, 2006.

The conference was held to celebrate forty years of related research achievement at the University of Waterloo. The Solid Mechanics Division (SMD) of the university was founded in 1966 as a research centre of excellence. During the next three decades, SMD hosted many scientific visitors from around the world and held more than a dozen international conferences, lecture series and symposia on a diverse range of topics in mechanics and structural engineering. Upon the retirement of many of its founding members in the 1990s, SMD was renamed the Structures, Mechanics & Construction Division (SMCD) to reflect the changing research interests of its newer members.

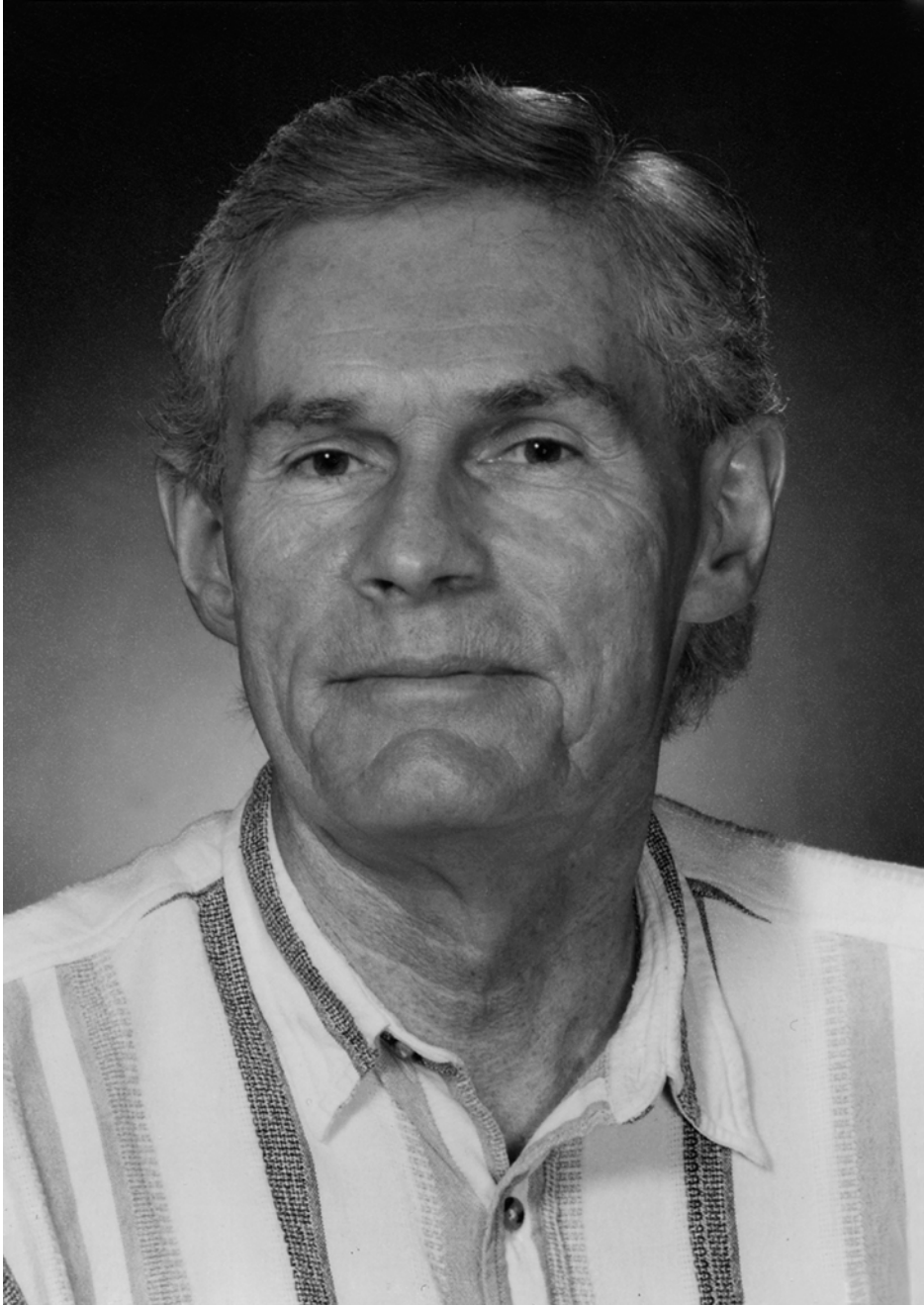
The conference also celebrated the academic career of Professor Donald E. Grierson as a distinguished researcher and educator. Professor Grierson has been a faculty member of the Department of Civil Engineering and SMD/SMCD of the University of Waterloo since 1968. He was an early contributor to the Solid Mechanics Division in the 1960s, and was pivotal in the reformation of the Structures, Mechanics & Construction Division in the mid of 1990s. After a productive career of thirty-eight years in research and teaching, Professor Grierson retired from the university at the end of 2005.

This book contains seventy-three papers in the areas of structural engineering, applied mechanics, and construction management. Most of the papers present original research results, while some papers present reviews of specific research areas. The contributors are from various parts of the world, yet most of them have a close tie with Waterloo. Some of them are former or current members of SMD/SMCD or their collaborators; some were graduate students, postdoctoral fellows, or visitors of the Division; some delivered courses to our graduate students; and others presented their research in the famous SMD/SMCD seminar series. The papers cover the entire research spectrum of the Structures, Mechanics & Construction Division: concrete structures, steel structures, cold-form steel structures, engineering mechanics, structural optimization, applied mathematics, engineering reliability, and construction management. The papers reflect the achievements and influence of SMD/SMCD over the past four decades.

We three editors of this volume are privileged to be members of SMD/SMCD since our graduate years in the 1980s. We are fortunate to be associated with Professor Grierson as former students, colleagues, and friends, and are delighted to be able to celebrate the 40th anniversary of SMD/SMCD and to honour Professor Grierson with old and new friends.

We acknowledge the Department of Civil Engineering, the Faculty of Engineering, and the University of Waterloo for their support of SMD/SMCD since its inception in 1966. We also appreciate their financial support for this conference and proceedings.

Mahesh Pandey, Wei-Chau Xie & Lei Xu
May 2006



Professor Donald Edward Grierson

DEDICATION TO PROFESSOR DONALD EDWARD GRIERSON

This volume is dedicated to Professor Donald E. Grierson to celebrate his long career as a distinguished engineer, researcher, and educator on the occasion of his retirement. Professor Grierson has been a faculty member in the Department of Civil Engineering at the University of Waterloo, Canada, since receiving his Ph.D. degree there in 1968.

Professor Grierson has held visiting appointments at various engineering institutions in North America and abroad, including the University of California at Berkeley in the USA in 1970/71, Imperial College in England in 1974, University of Liege in Belgium in 1975, Politecnico di Milano in Italy in 1975, University of California at Los Angeles (UCLA) in the USA in 1979/80, National Defense Academy of Japan in 1986, Heriot-Watt University in Scotland in 1991, the University of Brescia in Italy in 1992, the Technion-Israel Institute of Technology in 2001, and the Federal Institute of Technology, Lausanne (EPFL) in Switzerland in 2004.

In his thirty-eight years of academic career, Professor Grierson has carried out research and made significant contributions in many areas of structural engineering; among these are structural plasticity, structural optimization, evolutionary computing, failure-load analysis, fail-safe design, performance-based seismic design, design under abnormal loading, and computational conceptual design. Some of his notable contributions include deformation analysis of elasticplastic frames, optimal design of structural steel frameworks, optimal sizing, geometrical and topological design, and progressive-failure analysis of buildings subjected to abnormal loading. His erudite knowledge of structural optimization and profound insight into structural plasticity, engineering computing, and structural design have been amply demonstrated through his approximately 200 research articles in internationally renowned scientific and engineering journals, and conference proceedings. His research work and that of his students is the basis for structural steel design software used in North American engineering institutions and consulting offices since the 1980s.

Professor Grierson received the Canadian Society for Civil Engineering *E. Whitman Wright Award* in 1995 for excellence in computer-aided design. He was the co-recipient of the American Society of Civil Engineering *State-of-the-Art Award* in 1998 and 2004 for his contributions in structural optimization and optimal structural design. He was honoured by the Structural Engineering Institute of the American Society of Civil Engineering with the *Distinguished Service Award* in 2003. He has been a member of a number of professional societies, editorial boards of international scientific journals, international scientific committees and organizing committees for international meetings.

Not only is Professor Grierson a leading researcher in applied mechanics and structural engineering, he is also an eminent educator. Professor Grierson has given invited lectures at many universities and institutions, and has been a keynote speaker in a goodly number of international conferences. Professor Grierson has devoted his academic career to the promotion of the discipline of computer-aided structural analysis and design through teaching and training of highly qualified researchers. He has supervised nearly forty graduate students, many undergraduate research assistants, postdoctoral fellows, and visiting scholars. Professor Grierson's influence on students was enormous. Innumerable students and researchers have benefited through his lectures, presentations, discussions, and writings. Professor Grierson was an early contributor to the *Solid Mechanics Division*, and was instrumental in the reformation of the *Structures, Mechanics & Construction Division* of the

University of Waterloo. He has demonstrated exceptional leadership in mentoring young faculty members. His passion for teaching and dissemination of knowledge was honored by the Sandford Fleming Foundation *Teaching Excellence Award* in 2002 in recognition of an exemplary record of outstanding teaching, concern for students and a commitment to the development and enrichment of engineering education.

Professor Grierson's achievements over many years and in many ways demonstrate that his qualities as a scholar, educator, and contributor are of the highest level. His academic career as a researcher and teacher is exemplary for his colleagues and engineers of younger generations in terms of teaching and learning, research and scholarship, leadership and service to society.