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

Proceedings of an International Conference on Advances in Engineering Structures, Mechanics & Construction, held in Waterloo, Ontario, Canada, May 14–17, 2006

Edited by
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WEI-CHAU XIE
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and

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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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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
DEDICATION TO
PROFESSOR DONALD EDWARD GRIERSON

This volume is dedicated to Professor Donald E. Grierson to celebrate his long career as a disting-
guished 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

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 elastic-plastic 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 en-
gineering, 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 re-
searchers. 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.
Plenary Presentations
Initial planning for the formation of the Solid Mechanics Division (SMD) at the University of Waterloo began in 1966, and it was implemented into a formal entity following the award of a National Research Council of Canada Development Grant in 1968. Upon the departure and retirement of many of its initial members over the next thirty years, SMD was reconstituted in the mid-1990s as the Structures Mechanics & Construction Division (SMCD) to reflect the changing research interests of its more recent and new members. The collective research work of both SMD and SMCD has resulted in many publications and valuable contributions to the progress of engineering structures, mechanics and construction. This paper presents a 40-year historical perspective through to 2006 of this activity at the University of Waterloo.

1. Introduction

In the early 1960s, the University of Waterloo was only a few years old and its Faculty of Engineering was just about to produce its first graduates. D.T. Wright, the founding dean and subsequently the University’s third president, brought to the Faculty a number of promising scholars from around the world, and thus opened the prospects of vigorous progress in its innovative cooperative programs in engineering.

The Civil and Mechanical Engineering Departments acquired at the time a group of young faculty members eager to realize their academic potential and widen their research horizons. Under the leadership of A.N. Sherbourne, the next Dean of Engineering, new ways for enhancing existing capabilities of the two departments were explored. Their parallel or intersecting areas of activity in Mathematics, Theoretical and Experimental Mechanics, Soil Mechanics, Structural and Machine Analysis and Design, Material Science and Technology, etc., suggested that considerable benefits could be expected from closer cooperation and coordination of activities for groups with similar interests in the two departments.

Dean Sherbourne advanced the concept of bringing the above disciplines under a broad umbrella organism, that came to be known as the SOLID MECHANICS DIVISION (SMD), and initiated efforts to define its goals, structure and mode of operation, as well as means of formalizing its creation.

This paper describes the beginning, growth and maturing of SMD, as well as that of its successor, the STRUCTURES MECHANICS and CONSTRUCTION DIVISION (SMCD). The presentation gives a brief historical overview of these entities, offers a permanent record of results of their activities, examines the causes of related successes and failures, and draws some possible lessons from the first four decades of this academic experience.
2. Solid Mechanics Division (SMD)

2.1. Beginnings

Prompted by Dean Sherbourne, a group of UW faculty decided to formalize the voluntary cooperation of members in the Civil and Mechanical Engineering Departments into a research unit, the Solid Mechanics Division (SMD). Its goal was to establish a centre of excellence in solid mechanics at the University of Waterloo (UW) by enriching the existing research and teaching programs. While the main emphasis was placed on the human factor (i.e., attracting outstanding visiting professors, research fellows and graduate students), serious consideration was also given to modernizing laboratory facilities and expanding the working environment and supporting staff.

Implementation of these general objectives was detailed in an application to the National Research Council (NRC) for a major negotiated grant to UW, aiming at the creation and development of SMD. In April 1968, NRC announced the three-year award of Grant D-10 in the amount of $600,000. The funds were to be expended in installments of $100,000, $200,000 and $300,000 in each year of the award term. It was the understanding of the grant applicants and of the Dean of Engineering that, whereas Grant D-10 was to help establish SMD as a centre of excellence, by the very nature of the grant UW was committed to ensuring its continuing existence and development through appropriate support and funding at the end of the award term.

Thus, SMD was brought to life in the spring of 1968 by a decision of the University Board of Governors and the generous NRC award of Development Grant D-10. One of the first tasks of the SMD steering group was to establish an administrative structure that could implement the stated objectives under the terms of Grant D-10. After considering to offer the chair to a distinguished foreign academic, the group ultimately decided to nominate, and the Faculty of Engineering appointed, M. Z. Cohn to fill that position for three years.

The founding SMD membership included Professors S. T. Ariaratnam, D. J. Burns, R. Green, N. C. Lind, J. T. Pindera, H. B. Poorooshasb, A. N. Sherbourne, T. H. Topper, and the founding SMD Chair, M. Z. Cohn. Other members that joined SMD soon thereafter and over the next few years were Professors E. F. P. Burnett, R. Dubey, G. M. L. Gladwell, D. E. Grierson, K. Huseyin, H. H. E. Leipholz, G. M. McNeice, T. P. Prasad, J. Roorda, R. M. Schuster and J. C. Thompson. It is of interest to note that the initial and early SMD membership was comprised of individuals from several different departments of the faculty of engineering, including Civil, Mechanical and Systems Engineering.

The SMD founding group and chairman agreed on a few basic operational principles:

- Minimal administration and formalism;
- Expectation of performance from key members with authority and responsibility;
- Clarity of objectives for efficient implementation.

The SMD operation was to be ensured by the following elements:

- Executive Committee, responsible for planning, funding and deciding on all activities;
- Publication Committee, in charge of policy matters for production of SMD publications;
- Area Representatives, responsible for initiating and overseeing activities in each area of concern (i.e., structures, computer analysis and design, geotechnical, mechanics, experimental mechanics, etc);
- Task Officers, responsible for three SMD major tasks: Publications, Seminars and Library.
Main operational features were the complete decision transparency of its working committees and total initiative and authority of each task officer. Monthly SMD meetings - not exceeding one hour - were planned and rigorously held in order to keep members informed in a timely manner on all matters of general concern.

D. E. Grierson was appointed as Publications Officer, a capacity in which he served throughout the life of SMD. Over the years he was assisted by a dedicated production staff. A special contribution was brought by D. Bartholomew of UW Graphic Services who designed the SM Studies jackets and all publication formats. His response to our exigencies produced the SM Logo shown in Figure 1, that soon become our well-recognized and proud emblem on all SMD printed output.

![Figure 1. SM Logo](image)

Bi-monthly SMD Seminars, initiated and regularly held on Mondays at 3:30-5:00 p.m., became a permanent entry in our calendars. SMD staff ensured the conservation and growth of library collections that included our own publications series, as well as solid mechanics volumes and journals donated by members.

2.2 Growth

SMD vision and ambitious program became apparent with the number and variety of its printed and verbal expressions. The main evidence of success in its activities was the body of SM publications that began to be produced within a short time, including the SM Studies Series, SM Papers/Report Series, SM Special Publications and the SM Archives Journal.

2.2.1. SM Studies Series

This, probably the most important and widely known of SMD products, is a collection of publications intended to record major contributions by the SMD at UW in Applied Mathematics, Solid Mechanics, Structural Analysis and Synthesis, Experimental Mechanics, and Philosophy of Design. The SM Studies Series makes available works of academic merit which, because of their content or volume, may not be published by scientific journals or as independent books. These include proceedings of seminars and symposia, monographs, research studies and significant doctoral dissertations. (The jacket cover for the first SM Study is shown in Figure 2).

The SM Studies Series was conceived in order to confer a character of permanence to valuable work initiated and completed by SM members and their associates, work that might otherwise be lost or forgotten. The series was published under the direction of an Editorial Committee consisting of S.T. Ariaratnam, M.Z. Cohn, H.E. Leipholz, N.C. Lind, J.T. Pindera and A.N. Sherbourne, with the cooperation of a group of external Consulting Editors of international reputation.
Members of the Editorial Committee led their colleagues by example, by making repeated contributions to the Study Series and other SMD publications in their areas of expertise as follows:

S.T. Ariaratnam: Dynamics, Stochastic Processes, Continuum Mechanics
M. Z Cohn: Structural Plasticity and Optimization, Concrete Structures
N.C. Lind: Reliability, Codified Design and Risk Analysis
H.E. Leipholz: Stability and Mechanics of Continua
J. T. Pindera: Experimental Mechanics
A. N. Sherbourne: Steel Structures, Shell Analysis and Design

Other SMD members at the time also made contributions to the various SMD publications in their areas of expertise as follows:

E. F. P. Burnett: Building Sciences
D. J. Burns: Engineering Mechanics
R. Dubey: Mechanics of Materials
G. M. L. Gladwell: Applied Mathematics
R. Green: Bridge Engineering
D. E. Grierson: Structural Optimization
K. Huseyin: Stability
G. M. McNeice: Finite Element Analysis
H. B. Poorooshab: Soil Mechanics
T. P. Prasad: Applied Mathematics
J. Roorda: Structural Stability
R. M. Schuster: Cold-Formed Steel
J. C. Thompson: Experimental Mechanics
T. H. Topper: Materials Engineering

Figure 2. SM Study No. 1
Among the numerous Consulting Editors and friends of SMD and its publications, we remember the names of E. F. Masur (University of Illinois at Chicago), N. J. Hoff (Stanford University), C. P. Siess (University of Illinois), Ch. Massonnet (University of Liège), and M.R. Horne (Manchester University).

As the SM Studies Series became widely recognized, foreign scholars found it a congenial medium for disseminating results of their work and began organizing and publishing conference proceedings using SMD and UW Press facilities (e.g. see Appendix 1: Studies 12, 15, 16 and 17).

The reputation of SMD and its SM Studies Series may be attributed to its:

- Broad range and depth of areas covered;
- Quality of contributors and their contributions;
- Balance between theory and practice of engineering, classical and modern views, and fundamental and applied research;
- Innovative and outstanding doctoral dissertations (e.g., see Appendix 1: Studies 2 and 4).

It is worth mentioning that the graphic excellence of the SM Studies Series has been a major factor in its broad recognition, due in no small measure to the striking jacket design sporting the SM Logo in different colours for each volume. As listed in Appendix 1, eighteen volumes were published in this series between 1969 and 1988. (The jacket covers for two representative SM Studies are shown in Figure 3).

Figure 3. SM Studies 9 and 14
2.2.2. SM Papers, Reports and Notes Series

A second series of publications was the white-cover SM Reports/Papers Series, intended to ensure rapid dissemination, reaction and comment on papers prior to formal publication in refereed technical and scientific journals. As listed in Appendix 2, this series ran for 199 issues from 1969 to 1985. The series was initially called SM Reports, but its name was changed to SM Papers beginning with issue 101 in order to better reflect the nature of its contents. (The front cover of the first issue in the series is shown in Figure 4).

![Figure 4. SM Report/Paper No. 1](image)

The blue-cover SM Technical Notes/Reports Series was devoted to materials that deserved preserving for specialized study, but which, because of the type of information or volume, would not be normally published in standard periodicals. As listed in Appendix 3, this series ran for 31 issues between 1971 and 1980, and includes texts presented at various congresses, documents with extensive numerical or experimental data, and computer programs. The series was initially called SM Technical Notes, but its name was changed to SM Reports beginning with issue 15 in order to better reflect the nature of its contents. (Part of the front cover of the first issue in the series is shown in Figure 5)
### Solid Mechanics Archives

<table>
<thead>
<tr>
<th>Volume 1, No. 1, 1976</th>
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<tbody>
<tr>
<td><strong>S. K. Srinivasan</strong></td>
</tr>
<tr>
<td>Stochastic models for fatigue failure of materials</td>
</tr>
<tr>
<td><strong>C. E. Massonnet</strong></td>
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<tr>
<td>Forty years of research on beam-columns in steel</td>
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<th>Volume 14, Nos. 3 &amp; 4, 1989</th>
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<tr>
<td><strong>H. H. E. Leipholz</strong></td>
</tr>
<tr>
<td>Obituary: 1919 – 1988</td>
</tr>
<tr>
<td><strong>N. Sri Namachchivaya</strong></td>
</tr>
<tr>
<td>Instability theorem based on the nature of the boundary behaviour for one-dimensional diffusion</td>
</tr>
<tr>
<td><strong>S. A. Soliman and R. N. Dubey</strong></td>
</tr>
<tr>
<td>On stiffness matrices in finite element analysis of isotropic elastic Solids</td>
</tr>
<tr>
<td><strong>S. T. Ariaratnam and Ashwini Kumar</strong></td>
</tr>
<tr>
<td>On eigenmodal deformations in incompressible elastic solids under dead loads</td>
</tr>
<tr>
<td><strong>P. Labossiere and K. W. Neale</strong></td>
</tr>
<tr>
<td>On a parametric failure theory for fibre-reinforced composite Laminae</td>
</tr>
<tr>
<td><strong>T. Lekszycki and Z. Mroz</strong></td>
</tr>
<tr>
<td>Variational principles in analysis and synthesis of elastic systems with damping</td>
</tr>
<tr>
<td><strong>Tian-quan Yun</strong></td>
</tr>
<tr>
<td>Dynamic instability of axisymmetric dimpled shallow spherical Shells</td>
</tr>
<tr>
<td><strong>L. Librescu and N. K. Chandiramani</strong></td>
</tr>
<tr>
<td>Recent results concerning the stability of viscoelastic shear deformable plates under compressive edge loading</td>
</tr>
</tbody>
</table>

**Figure 5. SM Technical Note/Report No. 1**

**Figure 6. Contents of First and Last Issues of SM Archives Journal**
2.2.3. Solid Mechanics Archives

In 1976, SMD initiated and directed the publication of SM Archives, a quarterly International Journal, dedicated to original contributions to solid mechanics. It was printed with the cooperation of Noordhoff International Publishing, The Netherlands, and Oxford University Press, U.K. The Journal was under the direction of internal and external editorial boards, and appeared in 14 volumes until 1989. (The Contents for the first and last journal issues are shown in Figure 6).

2.2.4. SM Special Publications

Over the years a number of volumes were occasionally published outside the range of the regular SM series. These somewhat randomly-produced texts are of two distinct types:

- Lectures Sets given at UW by SMD members or visiting guests;
- Textbooks, Manuals, and Conference Proceedings sponsored by external agencies.

Some of these texts were organized and edited by SMD members, but produced by commercial publishers. A heterogeneous collection, the SM Special Publications cover a wide spectrum of interests within recognized SMD areas of expertise, while addressing an audience reflective of the international sponsoring organizations. A partial listing of the Special Publications is given in Appendices 4 and 5. (The partial front cover of a representative SM Special Publication is shown in Figure 7).

![Image](image_url)

**Figure 7.** Representative SM Lecture Set

2.3. Maturity

Processes of learning and sharing technical knowledge constituted the permanent focus of SMD activities, not only through the printed medium, but also by direct personal interaction of Division associates and visitors. Such interaction found its expression in various seminars, workshops, conferences and symposia, as well as lectures by invited guests on topics within the stated SMD mission.

A systematic listing of all SMD live-events is rather difficult to achieve because of the variety of venues (Waterloo or elsewhere), sponsorships (SMD, other, combined), publishers (UW or other), and orientation (research or teaching). A sample of the major events with SMD involvement is given in Appendix 6. The publication activities for these events have been surveyed in the preceding section. We now turn our attention to communication events of either research or teaching orientation.
2.3.1. Research-oriented Events

From the late 1960s to the early 1980s a number of topics in solid mechanics captured the interest of investigators around the world. At the time SMD was a centre of exciting developments in structural plasticity and optimization, reliability and codification, and stability and experimental mechanics. Interaction of SMD faculty, associates, students and friends allowed the planning and organizing at Waterloo of some notable international meetings on these topics. Images of the delegate participation at three such events are shown in Figures 8, 9 and 10.

Figure 8. NATO ASI- Engineering Plasticity by Mathematical Programming, Waterloo 1977

Figure 9. International Symposium- Nonlinear Design of Concrete Structures, Waterloo 1979
The first SMD meeting was the *Colloquium on Limit Design for Structural Concrete*, September 6-8, 1967. The purpose of the meeting was to clarify the theory and practical design application of three methods of Limit Design under debate by the joint ASCE-ACI Committee 428. The premises and feasibility of the three (European, American and Canadian) approaches were each discussed for one full day, with the basic principles presented by their authors during the morning sessions. Three representative structure examples, fully worked out by the Waterloo group of faculty and graduate students, were presented in the afternoon sessions. The latter results are summarized in the first issue of the SM Paper/Report Series (Cohn et al, 1969). The 1967 meeting was the beginning of an intense activity of live-events, whose contents and output is reflected by the Special Publications reviewed in the preceding section (see Appendix 6).

### 2.3.2. Teaching-oriented Events

The extent of advanced teaching by SMD and visiting faculty members may be assessed from the related printed documents listed in Appendix 4. While these lecture sets were mainly addressed to graduate audiences, SMD was equally interested in enhancing the overall quality of undergraduate teaching of solid mechanics at UW, consistent with its basic mandate. In this regard, during the 1969 summer semester SMD organized a weekly seminar cycle designed to stimulate undergraduate teaching excellence so that it would match our high graduate programs standards. Some of the problems and dilemmas identified but unsolved were mainly consequences of the distinctive features of UW’s engineering education, particularly the cooperative work-study program and the related academic calendar. Also of concern were the handling of the general knowledge explosion, new directions of study, and their accommodation within the curricula of standard four-year study programs. A fresh outlook on the design of undergraduate teaching seemed unavoidable if the following topics were to be properly addressed:

- Role of solid mechanics in CE and ME curricula;
- Nature of SM teaching output (engineers or engineering scientists);
Optimal teaching techniques (lecturing, problem solving, laboratory work, projects, TV sessions, etc.);
Optimal mix of various areas of study (mathematics, physics, computer techniques, theoretical and applied mechanics, etc.)
Objective teaching evaluation (“delivery” or “retention” models).

Specific questions pertaining to objectives, major topics, minimal ingredients, significance and optimal instructional media for each individual course were explored. Some of the major flaws identified in solid mechanics courses were: coverage of basic statics, insufficient laboratory work, poor understanding of physical problems and role of modelling, inefficient tutorials and insufficient engineering project work. Furthermore, it was strongly felt that lack of coordination of CE and ME offerings was manifest in unnecessary repetitions, omissions or redundancy, along with unsuitable textbooks and inadequate lecture-tutorial coordination.

A comprehensive discussion of the above problems took place in the framework of 12 weekly seminars during the 1969 summer term. Each seminar was devoted to one course presentation and full debate by faculty members and students with a view to:

- Establishing quality standards for the teaching process;
- Developing lecture notes, laboratory manuals, problem sets and other teaching aids tailored to the specific needs of UW students and their cooperative programs;
- Developing and completing within a few years an integrated set of *SM Textbooks* that encapsulated UW needs and standards, to be known as the SM Text Series.

The 1969 summer term SM Teaching Seminars were well prepared, attended and debated and generated productive discussion by the participants. Regrettably, the perseverance and long-term motivation required for bringing this major project to fruition were lost with time and the concept of a complete, modern SM Text Series, unified in format and educational perspective, failed to materialize. However, a lonely sample of the potential of this ambitious project saw the light of day in 1972 (Cohn 1972), and remains a prototype of what might have been the outcome of staying on course with our initial vision. (The partial jacket cover for the sole publication in the SM Text Series is shown in Figure 11).

Figure 11. SM Text No. G1
2.3.3. Visiting Scholars

The maturing of SMD is convincingly illustrated by its wide recognition by scholars from all continents and their interest in visiting UW for cooperative projects with our faculty and students. As it would be difficult to list all our distinguished guests and to identify the centres of learning with which SMD has established and developed most productive contacts over the years, we mention below only some of the most prominent guests.

Among many others, SMD was honoured to host such eminent personalities as W. Prager (University of San Diego), A. L. L. Baker (Imperial College, London), F. Levi (University of Torino), C. Menn (ETH, Zurich), J. Muller (Paris, France), G. Maier (Politecnico, Milano), F. Moses (Case Western University), Z. Mroz (Technical Research Institute, Warsaw), N. Khachaturian (University of Illinois at Urbana), and L. A. Schmit (UCLA).

2.3.4. Late Years

Three years after its promising beginnings and depletion of the funds awarded through NRC Grant D-10, the SMD autonomy started to be eroded; the promised continuing financial support by UW administration, implied by the negotiated grant, did not materialize; CE and ME departments favoured the parochial management of their traditional territories; SMD involvement in the planning and delivery of undergraduate programs was grossly misunderstood.

A 1972 UW Senate decision put an end to the formal existence of SMD. Its ongoing activities were to be carried out through departmental channels, with a small stipend granted from the CE department budget. SMD chairmanship was reassigned to H. E. Leipholz, who served from 1972 to 1979, when he assumed a senior position in the university administration. With the era of major initiatives and innovations being over, Leipholz must be credited for having maintained some of the activities and original SMD ways.

As a sign of the emerging hard times, SMD members volunteered to make individual financial contributions in order to sustain on a limited scale the planned projects and events. With SMD turning from a living organism to a surviving name and a bright memory, it became the task of G. M. L. Gladwell in 1979 to serve as the chair of the once proud and independent research group.

3. Critical Remarks

3.1. Successes

Statistical data regarding SMD activities can only give a limited view of its successes. Yet, it is noteworthy that in just the first three years of existence its printed output amounted to six SM Studies, one hundred SM Papers and fourteen SM Reports. During the same period it organized four major symposia and lecture series, and established a bi-weekly seminar series as a permanent forum for scholarly presentation and discussion. These accomplishments were multiplied within the next two decades of rather fragile survival, as shown by Appendices 1 to 6.

Beyond statistical facts, major successes must be credited to A.N. Sherbourne’s initiative of integrating individual strengths into a cross-departmental focused entity, and to SMD’s founding members for shaping it so that the division could represent more than the sum of its individual components. Indeed, in a short time span, the collective formal unit that embodied the members’ confidence, dedication and pride produced a noticeable rise in the level and dissemination of research results.
The principal SMD achievement consisted of living up to an uncompromising commitment to excellence, marked by a constant promotion of new young talent, individual growth, group development and international cooperation. The SMD reputation can be measured by the calibre of people associated with the wide range and high quality of its activities.

These were distinctive not only in substance, but also in a style expressed by the graphic standards and formats of its publications, as well as by the sense of occasion, attention to detail and meticulous organization of conferences. Not to be forgotten are the musical themes used as inspirational motifs, calls to order for working sessions or relaxing interludes.

What were the means that made possible the above successes? The essential factor was the rich reservoir of individual talent. But existing potential might not have materialized without the financial support of NRC Grant D-10. This award confirmed the viability of the SMD visionary program, energized its members and stimulated their creativity. Although relatively modest even by 1970s standards, the award funds were sufficient for initiating a large number of projects in a short time. However, we believe that, even with proper funding, SMD program could not have been implemented had it not been animated by the concepts of personal autonomy and responsibility, along with collective involvement and transparent leadership.

The establishment of the SMD Centre in 1972 in the E-4 (Pollock) Building had a very positive impact on the efficiency of its operation. Conceived, designed and furnished with active SMD participation, the Centre provided adequate space for SM faculty and graduate students, secretariat offices, library, lounge and a fully equipped seminar room. These facilities ensured precious proximity and improved the interaction among faculty, students and staff, as well as with laboratories and computer rooms.

3.2. Failures

Successes and failures can be assessed by comparison to either adopted or desirable objectives. By the first criterion SMD has to be characterized as an overall success, because it delivered on 100% of all contracted obligations.

By the second criterion, the projected self-imposed development and production of the SM Text Series, following the summer 1969 teaching seminars (see 2.3.2), ended as a serious failure. Completion of this project might have represented a unique contribution to the teaching of solid mechanics at the University of Waterloo. Ironically, while this initiative gave a constructive response to the often heard criticism that faculty members were more interested in research than teaching, it probably generated a political malaise responsible for the negative attitudes of Civil and Mechanical Engineering Departments toward SMD and its future. SMD efforts were aimed at reviewing the curricula, rationalizing inter-departmental programs and improving their implementation, without involvement in, or change to existing administrative structures. Sadly, departments misread our intentions, fearing an encroachment of their jurisdiction, power, and decision-making authority.

Beside the above, the critical SMD failure was an existential one. Although decisions on its fate were beyond the will and power of our group, a more outspoken response could have been given when SMD formal status was questioned and finally revoked. The UW reneging on the initial commitment to sustain its hard won centre of excellence brought disbelief, consternation, and eventual resignation to SMD membership.
It is fair to note that the political winds changed considerably during the short period of time since SMD inception: whereas the dominant orientation in the late 60’s was toward fundamental research and outward-looking, the early 1970s saw a switch to applied, nationally profitable research and development. UW followed the trend of chasing funding opportunities by downsizing long-term pursuits in favour of reaching tangible material benefits in the shortest possible time. It was in this climate that extensive debates took place on research policies related to basic vs. mission-oriented development, federal vs. provincial jurisdictions, the role of research in university vs. government labs, or industry. UW’s position may be inferred from the words of its Academic Vice-President at the time (Petch 1973):

There are three areas in which debate is still hot, with little indication that agreement will soon be reached: funding university research, organization of government research and stimulation of innovation in industry. (p.40)

Basic research has been one of the chief targets of those critical of the government’s policy, or lack of policy, on scientific matters. In moments of passion, some critics have suggested that Canada should divert all financial support to applied research and development and phase-out basic research. (p.36).

The demands for more mission-oriented basic research, applied research and development, arise because of a wide-spread feeling that Canada must utilize science and technology more in striving to achieve national goals, coupled with a new understanding that benefits do not necessarily flow automatically from free basic research, but require a conscious effort at application. (p.38).

3.3. Lessons

SMD was a memorable episode in the UW Faculty of Engineering: great talent and work pre-existed its creation and subsisted its demise. But its early years energized and brought out the best of existing potential and raised it to a level of high academic distinction and achievement. Not only did SMD live up to its commitments, but it amply exceeded the expectations of its founding members and caused our university to be recognized as a real force in the world of solid mechanics.

While we started this survey with the intention of factually recording the SM activities over approximately the last forty years, we may be excused if the intended writing objectivity has suffered occasionally: some of the old passion for SMD ideals could not be entirely eliminated while undertaking this memory trip.

Perhaps we may also be indulged in a little literary flight of fancy by viewing the SMD story as a real academic saga with not a few rather dramatic ingredients: indeed, on a close look, the evolving process of creation, development, stagnation and renewal are quite obvious. However, the less obvious conflicts of authority between an old departmental structure and a superimposed (perceived) rival new entity, jealousy and personality clashes, tradition versus innovation, loyalty and deception, growth, decay and redemption, all major themes of the classic drama are, or may be assumed, as part of this narrative. And so might have been pain, dissatisfaction, disappointment, and resistance to change, which are seldom absent at transitions from old to new.

Yet, in spite of all the ups and downs, a dominant leit-motif is discernible throughout the entire SMD project: fostering learning and inspiring human interaction between the old and the young, regardless of contingent circumstances. Whether funded adequately or not at all, the commitment to excellence was, and apparently will remain, the leading motivation of the UW group of scholars active in the fields of structures, mechanics and construction.