mechanics

Academia Americana de Mecánica • American Academy of Mechanics

Volume 31, Number 11-12 **November-December 2002**

(references in the form "M28(3-4)" indicate the last time the Journal was cited in *mechanics:* v. **28**, n. 3-4, in this case.)

mechanics

mechanics provides its readers with news in the field of theoretical and applied mechanics, and serves as a forum for the presentation and discussion of issues related to the development of the science and profession of mechanics. Opinions expressed are those of the authors and do not necessarily reflect official points of views of AAM or the institutions with which the authors are affiliated.

The *American Academy of Mechanics* is a non-profit corporation incorporated in 1969 under the laws of the Commonwealth of Pennsylvania. Its objective is to advance the science and profession of mechanics, with particular reference to the countries of North, South, and Central America. It aims to facilitate cooperation among mechanicists, to encourage recognition of achievements in mechanics, and to promote public understanding of the work of the mechanicist.

mechanics (ISSN 0076-5783) **POSTMASTER:** Send address changes to *mechanics*, Subscription and Membership, ESM, MC 0219, Virginia Tech, Blacksburg, VA 24061 (Tel. 540-231-6871: Fax 540-231-2290). Editorial and Advertising: Horacio D. Espinosa, Northwestern University, 2145 Sheridan Rd., Evanston, IL 60208-3111 (Tel. 847-467-5989, Fax 847-491-3915). Membership in the American Academy of Mechanics includes the subscription to *mechanics*.

American Academy of Mechanics
Academia Americana de Mecánica

SEASON'S GREETINGS FROM THE EDITOR

Dear Members of the American Academy of Mechanics,

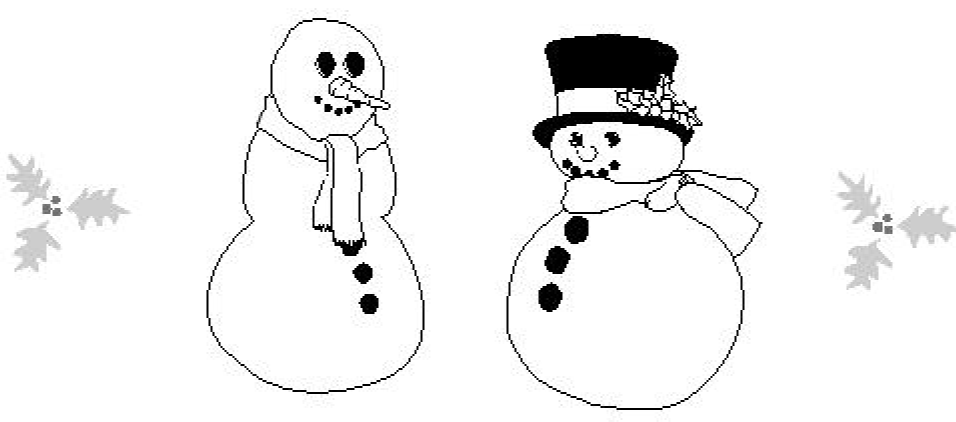
The Holiday season is upon us! It is the end of the year 2002 and I would like to take a moment to look back at the success of the American Academy of Mechanics. In particular, as Editor of *Mechanics*, I am especially proud of the increased participation of AAM members in contributing articles, news, and announcements. Without the gracious and dedicated support of everyone, *Mechanics* would not have such a broad readership as it does now. In the past year, I have had the pleasure of receiving five articles written by AAM members, of which three have been presented to date in *Mechanics*. In addition to the articles already contributed, I have also received commitments from six AAM Fellows. My thanks to everyone who has contributed!

As of November 1st, the AAM website <www.AAMech.org> requires a username and password to access *Mechanics* on-line. This information was sent to all AAM members by e-mail at the end of October. Also, a link has been added to the website under the link to PACAM VIII. This link provides information on travel to Cuba for U.S. citizens. Please take a moment to visit the AAM website as there have been numerous changes and updates.

Overall, it has been a wonderful and successful year. I wish everyone all the best for the coming New Year and look forward to the continued support and dedication in improving *Mechanics* and the website.

Greetings of the season and best wishes for the New Year!

Horacio D. Espinosa
Editor



POSITION OPENINGS

Faculty Position

The John and Bea Slattery Chair in Aerospace Engineering

Department of Aerospace Engineering
Texas A&M University

The Department of Aerospace Engineering at Texas A&M University invites nominations and applications for the John and Bea Slattery Chair in Aerospace Engineering.

To fill this prestigious position we are seeking candidates who have made outstanding contributions to one or more areas of research in aerospace engineering and have gained international recognition. We expect the selected candidate to actively participate in our undergraduate and graduate programs of education, conduct interdisciplinary and multi-disciplinary research within the Department, across the University and beyond, and provide academic leadership.

The Department of Aerospace Engineering has an undergraduate enrollment of over 500 and the current graduate enrollment exceeds 90. Affiliated with the department are the Aerospace Vehicle Systems Institute (AVSI) and the Commercial Space Center for Engineering (CSCE). The department is the leading participant in the newly established NASA URETI for Intelligent Bio-Nano Materials and Structures for Aerospace Vehicles. The research funding in aerospace engineering at Texas A&M University stands at more than $4 million in the year 2002. Please visit http://aeromaster.tamu.edu for further details on the department's activities.

Please send nominations or applications to:

Dr. Ramesh Talreja
Tenneco Professor and Head
Department of Aerospace Engineering
Texas A&M University
3141 TAMU
College Station, Texas 77843-3141
talreja@aero.tamu.edu

Texas A&M University is an equal opportunity employer

Faculty Position

Department of Aerospace Engineering

Texas A&M University

The Department of Aerospace Engineering at Texas A&M University invites applications for a faculty position in aerospace engineering. The appointment will be at a rank commensurate with the applicant's qualifications. An endowed position is also possible.

The position is related to activities within the scope of a newly established NASA URETI for Intelligent Bio-Nano Materials and Structures for Aerospace Vehicles. Particular areas of interest are nanomaterials, biomaterials, multifunctional material systems, active materials and smart structures, molecular simulation, multi-scale material modeling, and composites. The selected candidate will be expected to teach courses in one or more of the aerospace engineering disciplines such as mechanics and materials, and to conduct multidisciplinary research.

The Department has active research programs in solid mechanics and structures, aerodynamics and fluids, and dynamics and control, and is engaged in collaborative multidisciplinary research across campus and with other universities. Available within the Department and elsewhere on campus are research centers, laboratories and facilities such as Center for Mechanics of Composites, Center for Mechanics and Control, Materials Testing Laboratory, Intelligent Systems Laboratory, Polymer Technology Center, Center for Integrated Microchemical Systems, Laboratory for Molecular Simulations and Microscopy & Imaging Center.

Applicants should send a curriculum vita, a brief statement of their interests that includes their vision for research and teaching, and five references to

Dr. Ramesh Talreja
Tenneco Professor and Head
Department of Aerospace Engineering
Texas A&M University
3141 TAMU
College Station, Texas 77843-3141
talreja@aero.tamu.edu
http://aeromaster.tamu.edu

Stanford University

Department of Mechanical Engineering

Faculty Position

The Department of Mechanical Engineering at Stanford University invites applicants for a tenure-track faculty position at the junior level (Assistant or untenured Associate Professor) in the broadly defined area of mechanics. We are searching for an energetic and visionary individual in any area of mechanics, but we are especially interested in the following: multiscale modeling and simulation with application to materials, devices or biological systems; nano- and micro-scale mechanics; computational and solid mechanics.

Applicants must hold a doctorate in an appropriate field and must have demonstrated an ability to carry out outstanding research and have a strong record of, or promise for, exceptional teaching. Appointment will be at a rank commensurate with the applicant's experience.

Applicants should send a curriculum vita, a brief statement of their interests that includes their vision for their research area and teaching, copies of one or two publications, and complete contact information for at least five references, to the following address:

Professor Peter M. Pinsky
Department of Mechanical Engineering
275 Durand Building – 496 Lomita Mall
Stanford University
Stanford, CA 94305-4040

Applications are requested by November 30, 2002, but will continue to be accepted until the position is filled. Stanford University is an equal opportunity employer and welcomes nominations of women and minority group members and applications from them.

UNIVERSITY OF MINNESOTA

AEROSPACE ENGINEERING AND MECHANICS

The Department of Aerospace Engineering and Mechanics at the University of Minnesota anticipates filling a faculty position in the area of solid mechanics. The position is at the rank of assistant professor; exceptionally qualified candidates may be considered for appointment at the rank of associate professor without tenure.

We are searching for candidates whose research program will set promising new directions in solid mechanics. We are especially interested in candidates who use computational or experimental tools to bring fundamental atomic scale information to the study of the mechanical behavior of materials or structures. Candidates from any branch of mechanical science and engineering are encouraged to apply, as are candidates from physics, materials science, applied mathematics, biophysics, electrical engineering or solid state chemistry. The successful candidate must also be able to develop and teach undergraduate and graduate courses in aerospace engineering and mechanics.

Current research activities in the department include the study of active materials (such as shape memory and magnetostrictive materials), phase transformations, continuum mechanics, fracture mechanics and biomechanics.

Applicants must have earned a doctorate in a related field by the date of appointment; experience beyond the doctorate degree is desirable. The successful candidate will be expected to develop an independent, externally funded research program, and to participate in all aspects of the department's mission. Strong written and verbal communication skills are required.

It is anticipated that the appointment will begin fall, 2003.

Applicants should send a letter of application, detailed resume, and the names and addresses of three references to:

Solids Search Committee (IT1017)
Department of Aerospace Engineering and Mechanics
University of Minnesota
107 Akerman Hall
110 Union Street S. E.
Minneapolis, MN 55455

Application Deadline: The initial screening of applications will begin on January 1, 2003; applications will be accepted until the position is filled.

The University of Minnesota is an equal opportunity employer and educator and specifically invites and encourages applications from women and minorities.

Department Head
Department of Engineering Science and Mechanics
Virginia Polytechnic Institute and State University

The Department of Engineering Science and Mechanics at Virginia Tech invites applications and nominations for candidates for the position of department head. The Department of Engineering Science and Mechanics (ESM) is a unique department within the College of Engineering at Virginia Tech in that it views physical phenomena from a fundamental level rather than through specialization, as in other departments. The graduate program has an outstanding international reputation and stresses the classic disciplines of solid mechanics, fluid mechanics, and dynamics, and has been increasing course offerings in the biomechanics area. The department is also known for interdisciplinary research and educational activities with departments inside and outside the College of Engineering. The department offers Ph.D. and M.S. degrees in Engineering Mechanics, an accredited undergraduate degree in Engineering Science and Mechanics, and teaches core mechanics courses for the 10 other departments within the college. The department has 28 full-time faculty, an undergraduate enrollment of 70, a graduate enrollment of 90, and annual research expenditures of $6.5M. Screening of candidates will begin with the strictest of confidence on September 16, 2002 and will continue until the position is filled. A detailed description of the position and the nomination and application process can be found at **http://www.esm.vt.edu**.

Virginia Tech has a strong commitment to the principle of diversity, and in that spirit, seeks a broad spectrum of candidates including women, minorities, and people with disabilities. Individuals with disabilities desiring accommodations in the application process should notify Nancy Linkous, 540-231-3243(V), or by way of the Telecommunication Relay Service number, 711, 8 am – 5 pm Eastern US Time.

ANNOUNCEMENTS

ADVERTISEMENT POLICY

Upon the decision of the Board of Directors, an advertisement for a position opening is charged a flat rate of $200. Payment must be done only by check and sent to:

American Academy of Mechanics
Horacio D. Espinosa, Editor
Northwestern University
2145 Sheridan Road
Evanston, IL 60208
e-mail: mech1@clifton.mech.northwestern.edu

The FID number for AAM is 23-7045163. Make check payable to American Academy of Mechanics. Announcements for forthcoming events, conferences, and workshops are free of charge. Advertisements may be sent by FAX or e-mail (LaTex, MSWord, PDF or plain text). Logo of the institution may be included if the postscript (graphic file) is provided.

Mechanics is a bi-monthly magazine. To be considered for publication in forthcoming issues, an advertisement must be received one month in advance of the publication date. For example, an advertisement must be received before the end of November to appear in the January-February issue. Please note that the magazine is distributed at the beginning of the two-month period. The advertisement will continue to appear in future issues until the deadline of the position opening.

Visit the AAM website to read recent advertisements of position openings and past issues of Mechanics at http://www.AAMech.org.

MECHANICS On-line

To access *Mechanics* on-line, please visit

www.AAMech.org

Access to the on-line issues is restricted to AAM members. A username and password is required to access the on-line issues. This information was sent by e-mail to all AAM members. If you did not receive the username and password information by e-mail, please contact the Editor's Assistant, Thomas Milic, at the following e-mail address:
mech1@clifton.mech.northwestern.edu

American Academy of Mechanics

Founders Prize and Grant

Up to $10,000 For the Academic Year 2003-2004

(Deadline: July 1, 2003)

The American Academy of Mechanics is pleased to announce the availability of a Founder's Prize and Grant to be awarded in September 2003 to a doctoral candidate in the field of Mechanics. Funding has been arranged by the Robert M. and Mary Haythornthwaite Foundation through the good offices of Professor Haythornthwaite, founder and first President of the Academy. The aware will be made on the recommendation of an AAM committee. The prize consists of a Certificate and $1,000 that will be presented at the annual meeting of the Academy, usually held in November. The Grant will be made to that same person in two installments, $6,000 in September 2003 and up to $3,000 in January 2004, the latter dependent on the size of the approved budget and receipt by the AAM committee of an acceptable progress report. In order to encourage contestants to think constructively about the impact of new and pending developments, they will be asked to compose an original essay of no more than a thousand words under the title "Progress through Mechanics". The winning essay will be published in *mechanics*. The award is open to those who, as of July 1, 2003, are registered as graduate students at a degree granting institution within the Americas, have completed at least one year of full-time graduate study at that institution, have been assigned a thesis advisor at the institution and have had a doctoral thesis topic emphasizing mechanics approved by the institution following candidacy or equivalent procedures. There are no restrictions with regard to citizenship, residency, race, religion, or sex. Letters of support will be required of the thesis advisor and in addition one from either a Member or a Fellow of AAM. Contestants will be judged on the basis of the essay, plans, references and academic history. The intent of the Grant is to support the research of the student through an approved combination of equipment purchases, information access, travel, etc., but not routine living expenses or fees. Detailed rules for the competition will be issued soon: to receive them, express your interest to the committee by FAX to (215) 204-6936, or by writing to:

AAM Founders Prize and Grant Committee
c/o Civil and Environmental Engineering Department
Temple University (084-53)
Philadelphia, PA 19122

7th Meeting on Current Ideas in Mechanics and Related Fields CIMRF – 2003

The 7th Meeting on Current Ideas in Mechanics and Related Fields (CIMRF – 2003) will take place at Portland State University in Portland, Oregon, August 18 – 21, 2003. Like previous CIMRF meetings, this symposium will be concerned with broadly understood applications of mathematics and mathematical techniques to mechanics. However, the leading theme of this conference will be the mathematical methods (geometric, group theoretical, variational, PDEs) in mechanics of materials with special emphasis on representation and understanding the role of inhomogeneities, phase transitions, their creation and evolution.
Plenary lectures will be given by Richard James (University of Minnesota), David Owen (Carnegie-Mellon), and Gareth Parry (University of Nottingham).

Call For Papers

These participants who would like to speak at the meeting are requested to send a one-page abstract (in TeX/LaTeX, both the source file and the dvi file) by e-mail to Serge Preston at serge@mth.pdx.edu , with a copy to Marek Elzanowski at marek@mth.pdx.edu , no later than **June 30, 2003**. Abstract macro will be available on the conference website at http://www.mth.pdx.edu/~marek/cimrf/2003/cimrf2003.html

Registration

Those interested in attending this meeting, are kindly requested to submit as soon as possible a *pre-registration form*, which can be found at http://www.mth.pdx.edu/~marek/cimrf/2003/cimrf2003.html

Conference Fees

The Conference fee for CIMRF – 2003 is $240.00, if paid by money order sent directly to the organizers, and $260.00, if paid by wire transfer. The conference fee includes the welcome reception planned for the evening of August 17th, coffee breaks, conference banquet on Wednesday, August 20th, and the book of abstracts.
Prospective participants are requested to send, preferably before **May 30, 2003**, an international money order, payable to CIMRF2003, to Marek Elzanowski, Department of Mathematics and Statistics, Portland State University, P.O.Box 751, Portland, Oregon 97207, U.S.A. The conference fee ($260.00) can also be paid directly to CIMRF2003 at US Bank, routing number: 123000220, account number: 153691205261.

Housing and Travel Information

Information about local hotels, travel directions, weather, local attractions etc., can be found on the conference website at http://www.mth.pdx.edu/~marek/cimrf/2003/cimrf2003.html

Marek Elzanowski (Portland, marek@mth.pdx.edu)
Marcelo Epstein (Calgary, epstein@enme.ucalgary.ca)
Serge Preston (Portland, serge@mth.pdx.edu)

PACAM VIII

Eighth Pan American Congress of Applied Mechanics

January 5-9, 2004
Havana, Cuba

http://www.pacam8.mcgill.ca/

The Eighth Pan American Congress of Applied Mechanics (PACAM VIII), jointly sponsored by the University of Havana, the Institute of Cybernetics, Mathematics, and Physics of Cuba, and the American Academy of Mechanics, will be held January 5-9, 2004 at the Convention Center, Havana, Cuba. The Honorary Chairman of the Organizing Committee is Prof. Alina Ruiz Jhones of the University of Havana. The Co-Chairmen are Prof. Martin Ostoja-Starzewski of McGill University and Prof. Reinaldo Rodríguez-Ramos of the University of Havana. The Chairman of the Editorial Committee is Prof. Julián Bravo-Castillero of the University of Havana, and the Chairman of the Local Arrangements Committee is Prof. Raúl Guinovart-Diaz of the University of Havana, Cuba.

The aim of sponsors is to promote progress in the broad field of mechanics by (1) exposing engineers and scientists, including graduate students, to new research findings, techniques, and problems, and (2) providing opportunities for personal interactions between mechanicians of North and South America, as well as other continents. It is the only conference sponsored by the American Academy of Mechanics (AAM).

The Pan American Congresses of Applied Mechanics are held every two years early in January, always in a Latin American venue, at a time when few other conferences are scheduled. The previous Congresses were held in Rio de Janeiro, Brazil in 1989; Valparaiso, Chile in 1991; São Paulo, Brazil in 1993; Buenos Aires, Argentina in 1995; San Juan, Puerto Rico in 1997, Rio de Janeiro, Brazil in 1999 and Temuco, Chile in 2002. Participants come from the Americas as well as Africa, Asia, Australia, and Europe.

Persons willing to organize special sessions in any area of mechanics are welcome to contact the organizers listed below. All the future announcements will be made at the website listed above, and through the AAM (http://www.AAMech.org/). Four-page papers for the conference proceedings will be due June 30, 2003, at either address:

Latin American Co-Chairman
Professor Reinaldo Rodriguez-Ramos
Facultad de Matematica y Computacion
Universidad de la Habana
San Lazaro y L, Vedado, CP 10400
La Habana, Cuba
reinaldo@matcom.uh.cu
http://www.uh.cu

North American Co-Chairman
Professor Martin Ostoja-Starzewski
Department of Mechanical Engineering
McGill University
817 Sherbrooke Street West
Montreal, PQ, Canada H3A 2K6
martin.ostoja@mcgill.ca
http://www.mcgill.ca

Note on travel to Cuba from the United States – a link has been provided on the PACAM website that shows travel **is** possible to Cuba from the United States.

IUTAM Symposium On Integrated Modeling of Fully Coupled Fluid-Structure Interactions Using Analysis, Computations, and Experiments

1 June-6 June 2003

New Brunswick, New Jersey USA

http://cronos.rutgers.edu/~mechaero/iutam

Chairs:

Haym Benaroya and Timothy Wei, *Rutgers University*, New Jersey
benaroya@rci.rutgers.edu and twei@rci.rutgers.edu

Scientific Committee

Peter Bearman, *Imperial College of Science*, Technology and Medicine, UK
Earl Dowell, *Duke University*, North Carolina
Helmut Eckelmann, *Georg-August-Universität*, Germany
Peter Monkewitz, *IMHEF-EPFL*, Switzerland
Michael Païdoussis, *McGill University*, Canada
John Sheridan, *Monash University*, Australia
H.K. Moffatt, *Isaac Newton Institute for Mathematical Sciences*, UK

This Symposium will provide a forum for the latest thinking in analytical, computational and experimental modeling of structures interacting with fluid environments. The specific objective is to provide a structured format in which meaningful and lasting dialogues can be facilitated between leading researchers in the different component disciplines. It is intended that, through these dialogues, multidisciplinary linkages will be established leading to integrated approaches to modeling the complex, nonlinear interactions between fluids and structures. Examples of classes of interactions that may be addressed in this Symposium include ocean structures, fluid conveying structures, and aerospace structures. The energy transfer processes are inherently nonlinear in all aspects of the behavior. The important class of vortex-induced oscillations has regions of lock-in, where the structural natural frequencies rather than the fluid velocity govern the shedding, and there exists hysteretic behavior. The real fluid-structure system is one of complex exchanges of forces and energies, resulting in highly nonlinear behaviors. The ability to model, solve and test fully coupled fluid-structure systems portends a rich and profound understanding. In fact, recent research efforts have indeed started to focus on the development of fully coupled models. This Symposium is therefore a response to these new and exciting developments in the field. By bringing together a critical mass of key researchers in each discipline, and organizing the program to focus on multidisciplinary problem solving, this process of developing fully coupled fluid-structure interaction research programs can be reinforced and enhanced. We look forward to receiving abstracts for review, presentation, and eventual full publication, of topics that fall within the broad framework defined above.

DEADLINES

Submission of Abstracts: 1 February 2003
Notification of Acceptance: 15 March 2003
Hotel & Symposium Registration: 1 May 2003
Symposium: Sunday 1 June – Friday 6 June 2003
Final Manuscripts Due: Friday 13 June 2003 (FIRM)

19th Canadian Congress of Applied Mechanics
An International Symposium

University of Calgary
Department of Mechanical and Manufacturing Engineering

June 01 - 06, 2003

General Information
The 19th Canadian Congress of Applied Mechanics is organized by the Department of Mechanical and Manufacturing Engineering, University of Calgary, and will be held in Calgary, Alberta, Canada during June 01 – 06, 2003.
The objective of the Congress is to provide a forum for engineers and scientists to exchange ideas and extend further cooperation. The conference enables researchers and engineers to meet at one place, where they present their papers and conduct discussions.

Keynote Speakers
Dr. T. Brzustowski (NSERC, Canada); Dr. R. Ethier (University of Toronto, Canada); Dr. P. Glockner (University of Calgary, Canada); Dr. J.D. Humphrey (Texas A&M, USA); Dr. Katherine Park (Harvard, USA); Dr. P. Podio-Guidugli (University of Rome, Italy); Dr. D. Steigmann (University of California-Berkley, USA); Dr. L. Truskinovsky (University of Minnesota, USA); Dr. K. Wilmanski (Weierstrass Institute for Applied Analysis and Stochastics, Germany)

Conference Main Topics
The conference will feature invited lectures and presentations of contributed papers. Provisional sessions are as follows:

Advanced Materials, Analytical Dynamics, Biomechanics, Computational Mechanics, Configurational Forces, Continuum Mechanics, Control and Robotics, Elasticity, History of Science, Emerging Fields, Fluid Mechanics, Fracture Mechanics, Geomechanics, Heat and Mass Transfer, Manufacturing Systems, Solids and Structures and Thermomechanics.

Schedule
Participants who wish to contribute are requested to submit an original (two page) short paper containing the full institutional address as well as the proposed session proposal by **December 31, 2002**, to:

Dr. Les J. Sudak
CANCAM 03
Department of Mechanical and Manufacturing Engineering
University of Calgary, 2500 University Drive, NW
Calgary, Alberta, Canada
T2N 1N4
Email: CANCAM03@ucalgary.ca

Interested authors can obtain further information regarding submission of papers from the internet address http://www.enme.ucalgary.ca/cancam03

Inquiries regarding the program should be directed to Dr. Marcelo Epstein via email at epstein@enme.ucalgary.ca or by phone at (403) 220 – 5791

FOURTH INTERNATIONAL SYMPOSIUM ON VIBRATIONS OF CONTINUOUS SYSTEMS

The Fourth International Symposium on Vibrations of Continuous Systems will take place in Keswick, England, July 7-11, 2003. The primary goal of this Symposium is to bring together outstanding experts in the field of vibrations of continuous systems from all over the world, to discuss technical topics in a very informal atmosphere. As before, participation will be by invitation only, and will be limited to maximum numbers of 50 participants and 40 presentations.

The Symposium is devoted to the vibrations of continuous systems (e.g. strings, rods, straight and curved beams, membranes, plates, shells, and three-dimensional bodies). Examples of topics to be considered include: free and forced vibration, linear and nonlinear vibration, undamped and damped vibration, fluid-structure interaction, and structural elements of composite material.

The Symposium location, Keswick, is in the heart of the Lake District of northwestern England, famous for its beautiful lakes and hills. Typical days at the Symposium will consist of morning hikes or bus excursions, presentation sessions in the afternoons, and social gathering times in the evenings. The outings and social gatherings have proved to be excellent ways of generating relaxed and informal technical discussions and friendships which have been of great value to ongoing research.

Individuals who are interested in taking part in this Symposium should write to:

Professor Arthur W. Leissa
General Chairman, ISVCS IV
Dept. of Mechanical Engineering
206 West 18th Ave.
Ohio State University
Columbus, Ohio 43210
USA

Letters should be accompanied by a one-page summary of the writer's research accomplishments (include a list of published books, papers, reports, etc.) in the theme of this Symposium.

SELECTIONS OF THE EDITOR

Fifth International Congress on Advances in Civil Engineering, September 25-27, 2002
Istanbul Technical University, Istanbul, Turkey

CIVIL ENGINEERING

Senol Utku*
Prof. Emeritus, Dept. of Eng'g. Sciences, Istanbul Technical University, Turkey
Prof. Emrts., Dept. of Civil & Env'l. Eng'g. and Dept. of C.S., Duke University, USA

Abstract
Civil engineering aims to protect humans and their creations from the dangers of natural and artificial processes with minimum disruption of nature. Starting from this definition of civil engineering (which may be derived from observations of civil engineering products over time and space), the present work attempts to identify the trends in the profession. Because of the increase in the human population and the faster propagation of ideas, products and people between any two points on the planet, the role of civil engineering in the well being of human societies is becoming more pronounced. Knowledgeable young engineers, especially civil engineers, of higher ethical-standards and peoples' awareness of modern technology are increasingly enhancing the well being of human beings everywhere. This trend is further enhanced due to the increasing rate of progress in the sciences, engineering and education, as well as breakthroughs in the availability of energy, materials, sensor, processing and communication.

Introduction
The goal of civil engineering, as in any other field of engineering, is to construct products in its own domain for constructive human use. Deferring the discussion of the identity of the domain of civil engineering and the distinguishing attributes of civil engineering products to the next section, it is important that I begin by initially discussing the term "engineering product" and its qualifier "constructive human use".

An engineering product is the result of a set of activities in the engineering profession. It can be an electronic gadget, a machine part, a bridge, an automobile, a space-craft, an airplane, a ship, a sky-scraper, a blue print representing some design, a code for design, an operations manual, and so on. The modern world is full of engineering products. They are created to increase the efficiency of human beings in meeting their needs in the physical world, such as moving from point A to point B, finding food/water/air, creating new food/water/air resources, and protecting life and property against the elements and other people. These are perhaps very low-level needs; yet they are very basic and very common. Without the satisfaction of these needs, we cannot exist.

The qualifier "constructive human use" means that the product of civil engineering will be used for the purpose for which it was designed.[1] Ensuring a constructive human use of a product

* AAM Member

depends on educating people on its intended purpose. When the cost of misuse of a product becomes exorbitant, it must be redesigned to minimize or totally eliminate the possibilities of misuse.[2,3]

Confining ourselves to considering products created by human beings (as opposed to the products created by nature), we may sort these products using the criteria of their usefulness in assuring the survival of humans over time. Since an engineered product that is useful at a specific time and a place may become harmful in another context, such a sorting process requires a thorough knowledge of human beings and their long time response to similar products in past experience. Modern technology and sciences are helpful in this process.[4,5,6] However, as has happened many times in the past, a locally beneficial product may be falsely promoted as a globally beneficial one. Periodic critical scientific reviews of the performances of such engineering products may help in continually evaluating their long-term global usefulness.

Products are the result of human creativity. They should be encouraged to proliferate as long as they fulfill some human need. However, human beings and the planet they live in should not be materially harmed, either because of their production or their use.

In the next section, the distinguishing attributes of civil engineering and the domain of civil engineering products are discussed. The third and fourth sections discuss the issues of civil engineering design and review and the role of the sciences against the background of the technological breakthroughs of the last fifty years. The fifth and the sixth sections consider the issues of engineering design implementation and operations. The last section reviews trends in civil engineering and civil engineering products considering the earlier discussions.

Civil Engineering Products

Among all fields of engineering, civil engineering strives most to satisfy the basic needs of human societies in the physical world and to assist the harmonious development of these societies. The label *"civil"* engineering clearly implies this.

It is disappointing that in some languages the term used for "civil engineering" does not fully express the role of the field in not only improving the quality of human life but also defending

---

[1] An ocean-crossing airplane, for example, should be used as a vehicle to move people across oceans, not as a guided missile.

[2] For example, in order to avoid unfortunate events like September 11, modern technology can be used to transfer the controls of continent and/or ocean crossing-aircraft to autopilots when the aircraft abandons its planned trajectory.

[3] Guns, which are being misused in some societies, need to be redesigned by using modern technology to prevent such misuses or, at least, to help identify the misusing person(s).

[4] Take for example "cigarettes": a wonderfully manufactured, packaged and marketed habit-forming product. This product has wide appeal because it helps to control stress; however, it is harmful to health. When this product began to be mass-produced in the Twentieth Century, it provided jobs and wealth to many people, and misery to many more.

[5] Atomic bombs were manufactured and used at the end of the Second World War to end the war. However, in the ensuing years, nuclear weapons endangered the entire human race, and their manufacture polluted the world at unprecedented scales.

[6] It seems many people cannot do without cars. They are wonderful devices for transportation. Many people owe their livelihoods to them. However, their detriments may presently outweigh their benefits as a device for moving people from a point to another point: they have become air-polluting, killing machines and have caused people to believe that it is normal to move tons of steel for the purpose of moving a 100 kg individual and to lose 50,000 people per year in traffic deaths in the U.S.A. alone.

human life itself [7,8]. The totality of civil engineering products is a measure of the degree of civility of human societies. This point should not be missed either at the scale of the collective wisdom of humanity or during the teaching of the profession to new generations[9].

Civil engineers all over the world try to meet the same set of basic needs of human societies. In this sense, the civil engineering profession is as global and as borderless as the medical profession. The medical profession works for the betterment of the health of individuals, whereas the civil engineering profession works for the betterment of the general welfare of societies in its respective domain.

The domain of civil engineering is the physical world[10] that we conceive directly through our senses. Human beings clearly should not destroy the physical world that they inhabit. Civil engineers, through their products, strive to help human beings relate harmoniously with their physical world while they live and create.

Only a century ago, civil engineering was perceived as a profession to help humans dominate the physical world. Presently, it is perceived more like a profession to protect the physical world from excessive human intrusion. Considering the tripling of the human population during the last three quarters of a century, one should not be surprised by this change of attitude. In order to provide the services that had been available to only a few in the past to a much greater number of people, industrial outputs have had to increase. As a result, the quality of the air we breathe, the water we drink, and the food we eat has dropped to levels causing serious health problems. This occurrence proved sufficient warning for civil engineering to pay greater attention to the environment. The enlargement of the "sanitary engineering" component of civil engineering into the discipline of "environmental engineering" was the profession's proper and rather swift response.

With this change of labels, civil engineering may be more broadly viewed as a profession that operates on the interface between humans and their habitat. A work of civil engineering requires the protection of each of these entities from the other, whereas both entities are required for the survival of the human species – i.e., shelter for humans from the elements and preservation of the environment humans inhabit (Norris, 1976). Thus, civil engineering products must meet the needs of both humans and nature. This is probably the most salient attribute that distinguishes civil engineering products from other products. Civil engineers cannot use labels such as "for

---

[7] In modern Turkish, *insaat muhendisligi* is used for civil engineering. This label translates more accurately as "*construction engineering*" rather than "*civil engineering.*" Istanbul Technical University, during the period 1883-1909 used the label "*hendese-i mulkiye*", which more closely connotes "*civil engineering*."

[8] The Civil Engineering Department of University of Kyoto, Japan initiated a search for a more meaningful label in the early 1990's to suggest the global attributes of civil engineering – e.g., labels such as *planetary engineering, etc.* The move created some apprehension among the Civil and Environmental Engineering faculty at Duke University at that time, because of the possible loss of the qualifier "*civil*" that has traditionally been used to designate the profession.

[9] According to recent data, mankind is spending close to one trillion dollars per year for weapons and war products under the label of defense. This author refuses to believe that people are as violent as this figure suggests. Imitation is a part of human nature - the following quotation from Lord A. Tennyson expresses this best: "I am a part of all that I have met". If a society that is in a leadership position behaves violently, then in due time, all societies will become violent.

[10] As opposed, e.g., to the spiritual world.

indoors use only" or "for use in Yucca Mountain only" on their products. Since the domain of civil engineers is the whole world, they cannot cry *"NIMBY."*[11]

Design is a prerequisite to the creation of a product of engineering. Design is a process that culminates in blue prints and/or design documents that instruct technicians on how to create the product using available technology. The design documents in most engineering fields allow one to efficiently produce a product in multiple quantities. However, civil engineering products are unique – normally only one civil engineering product is created from a blueprint. For civil engineering products, the design documents are useful in the future maintenance of a product, prospective alterations of the product and in the initial design phases of future products. The design cost of a civil engineering product is higher and the design-completion time is longer compared to other engineering products. This is because a civil engineering product (e.g., a pipeline or a municipal damp), unlike a product of another engineering discipline (e.g., a chip embedded in a computer) interfaces more directly with the physical world and the social world, which are each hard to predict and which often exhibit chaotic behavior.

The Designer of Life is clearly the best engineer – Its products are such that the corresponding blue prints and operation manuals are embedded in each product. These embedded blueprints and operation manuals operate upon abundantly available materials in the habitat of the product to manufacture and later manipulate the product, to ensure the continued survival and propagation of the product in an ever-changing habitat. The accumulation of the evolutionary experiences of a species through the process of mutation and natural selection over time may be viewed as a process in which the blue prints of the product are modified slowly to adapt to a slowly changing environment to prevent extinction of the species. Civil engineers, perhaps like all engineers, imitate nature by adapting new technologies and assuming new responsibilities in their designs to ensure the continued functionality of the product, or of other products based on that product.

As in any other engineering product, the material used in manufacturing the product plays a very important role in the design. However, each time a new engineering material becomes available, new products may be readily created through the use of aspects that are invariants of the design, such as principles and laws of nature, that are provided by the sciences, and especially by the engineering sciences.

Life learns the nature of its environment by the individual experiences of successive generations of its products over eons. Science strives to discover these underlying principles in a much shorter time through experimentation, and passes these to engineers in the form of engineering principles, or more quantitatively, *excitation-response relations*. The design of civil engineering products requires knowledge of the corresponding excitation-response relations so that these products may function properly in the physical, chemical and biological worlds in which they are embedded. Civil engineers use the relevant excitation response relations to predict and assess the responses of their products to future possible states of the environment.

---

[11] NIMBY – which designates the phrase "Not In My Back Yard", is used to describe a public attitude in which facilities that are necessary for the public good (e.g., a municipal dump) should not be located in one's own backyard.

Design Process

Design is a necessary step preceding the actual production stage of any engineering product**.** The act of design of a product requires a clear definition of the following attributes of the product: (1) *function*, (2) *nominal state*, (3) *environment*, and (4) *design life*. A short discussion of these attributes follows.

Every engineered product has a corresponding specific *function*. For example, a television is designed to display images that are broadcast from a specific location at a prescribed frequency on its screen with a sufficiently adequate resolution and with a sufficiently small time lag. The function of a dam is to safely retain a prescribed maximum amount of accumulated water; the function of a road is to safely carry a prescribed maximum volume of vehicle traffic at a specified speed range; the function of a sewage processing plant is to filter pollutants from inflowing sewage at a prescribed rate etc.

The sole purpose of an engineered product is to perform its function. The users of a civil engineering product must be aware of its function at all times. Because many people normally share civil engineering products, societies have the responsibility to clearly educate their citizens in their proper use, and ensure that their corresponding functions are not improperly distorted or disrupted. On the other hand, the designer of a civil engineering product has the responsibility of ensuring that the product be able to fulfill its function through out its *design life*.

The *nominal state* of a product is the state in which the product remains during most of its *design life*. For example, the nominal state of a bridge may be defined by specifying an average live load; the nominal state of a sewage plant may be defined by an average affluent content and flow rate; the nominal state of a dam may be specified by an average volume of stored water; the nominal state of a highway may be specified by an average flux of vehicle traffic etc.

Because the cost of an engineering product depends on the specified nominal state, the nominal state must be defined precisely. In particular, a designer cannot begin designing until the nominal state of the product is defined quantitatively. Further, the precise definition of the nominal state of a product has social implications: Because civil engineering products are intended to meet social needs, the citizens of the society paying for the product must be educated properly about the nominal state of the product in order to prevent false expectations.[12] A civil engineering product is supposed to enhance social harmony, not create social unrest.

Our environment is continuously changing. So is the product's environment. A designer must with sufficient confidence understand those attributes of the *physical, chemical, biological, and social environment* that interact with the product throughout its design life. Attributes of the environment that interact with the product cause deviations from the product's nominal state. A good design is the one that keeps these deviations acceptably small so that the function of the product is not compromised, and the product itself does not negatively affect its environment in any way – if it does, such a negative effect should be as local as possible.

Every engineering product is designed to function as required within a prescribed time interval called the *design life* of the product. The designers of the pyramids in Egypt considered the

[12] For example, the designers of a bridge built in 1970 with a design life of 30 years and a nominal state corresponding to a traffic flux of 50,000 vehicles/day may be unfairly criticized in 2010, when the traffic flux increases to 500,000 vehicles/day.

design life of their product to be infinite. Apparently, they did a good job because their products are still around. Modern engineers may be wiser in their awareness that there are upper bounds on the design life of any engineering product within which the product is capable of fulfilling its function. Moreover, with their realization of the rapid advance of technology and their awareness of the exponential increase of cost with increasing design life and the unpredictability of future environments of the products, modern societies are much less ambitious in designating the design life of civil engineering products than their counterparts in ancient Egypt. The design life of current civil engineering products are usually on the order of magnitude of an average human life time or shorter. Nevertheless, the design life depends on the type of product considered. The specification of the duration of the design life is of critical importance in the design process.[13]

The greatest challenge in design is to keep the product within an acceptably close neighborhood of its nominal state, despite the fact that the product's environment keeps changing through out the design life. The designer of the product must estimate future states of the environment in which the product is embedded[14]. By continuously observing the environmental attributes that interact with the product, keeping quantitative records of these and using statistical tools to analyze such data, engineers and scientists strive to probabilistically predict the future states of these environmental attributes.[15] The success of such predictions depends on the frequency and spatial density of reliable measurements, as well as the duration of such observations. Advances in sensor, microprocessor and space technologies and international scientific cooperation are resulting in more reliable and better predictions of future states of the products' environment.

In order to complete the design of the product, the designer must ensure its functionality throughout its design life. For this, the designer studies the product's behavior in its design life by modeling and/or simulation and using estimates of future states of the environment. This is the *passive design* methodology that engineers have been using successfully for the last three centuries (see, *Introduction,* Norris, 1976).

To partially decrease the risk of relying too heavily on the predicted future states of the environment, engineers are now also able to use *active design* techniques, thanks to the advances in sensor, actuator and microprocessor technologies. In the active or adaptive design, the designer engineers the product to remain within an acceptably close neighborhood of its nominal state by active means when environmental changes from the nominal are sudden and/or excessive. In this methodology, the product is designed using classical design techniques in accordance with a predicted average future state of the environment (i.e., the nominal state of the environment), but is equipped with appropriately placed sensors, actuators and an on-board processor. During the design life of the product, deviations from a predetermined neighborhood

[13] The design life of monumental buildings, like the *Anit Kabir* [the mausoleum for Mustafa Kemal Ataturk (1881-1938), founder of Turkish Republic] in Ankara, Turkey, was specified as being longer than the design life of other contemporaneous buildings. On the other hand, the design life of a commercial building is dependent on net present value of future commercial returns from the building as estimated at the time of design i.e., the cost corresponding to the design life should be less than the net present value of the future returns.

[14] One may humorously contend that, theoretically, a good designer should be either a fortune-teller who predicts future changes or a religious conservative who believes that the world will remain unchanged as described in holy books, and at the same time a political conservative who tries to keep social attitudes from changing.

[15] For example, the *United States Geodesic Survey (USGS)*, and the *National Aeronautics and Space Administration* (NASA) are only two of the many reliable scientific and engineering institutions in the United States that keep track of changes in the physical world.

of the nominal state are measured by the embedded sensors, and are compensated for by means of the actuators in real time under the control of the on-board processor. This process is repeated periodically at an appropriate frequency throughout the design life of the product.

Because of their importance, the passive design and active design methodologies are further discussed below.

Passive Design

At the beginning of the design process for a product, the nominal state of the product is only partially known. The design process determines the missing information, which is called "free-design parameters." For example, the size of the cross-sections and the steel reinforcement percentage of a uniform reinforced concrete frame are free parameters of its design.

In classical design, the free-design parameters are estimated and are used to determine whether they are adequate by using (a) excitation-response relations furnished by engineering sciences and specialized for the product, and (b) estimates of the future states of the environment. Engineers use hand computations or powerful digital simulation software to obtain the state of the product corresponding to a given future state of its environment. The engineer usually repeats this process in order to calculate the deviations from the product's nominal state for all possible future environmental states. If one or more deviations are not acceptably small, then the free-design parameters are re-estimated and the calculations are repeated until all deviations obtained are acceptably small. When all of the free-design parameters have been determined in this way, the design process is complete and production may begin (Norris, 1976).

Without digital simulation software based on the principles provided by the engineering sciences, the designer would be forced to use hand computations, and the design process would be very lengthy and tedious. Confronted with such difficulties, engineers of the pre-computer era would obtain responses of the product by actually building a physical model of the product with estimated values of the free-design parameters, simulating a few selected future states of its environment and measuring the product's responses in laboratory conditions. This method is much more expensive and much less accurate than obtaining the responses using the simulation software of the computer era.

As mentioned above, engineering simulation software is based on the excitation-response relations provided by engineering sciences and uses the *retrieve-process-store cycle* of digital computers as many times as required by the chosen mathematical procedures in order to obtain a future state of the product corresponding to a selected future state of the environment. The confidence in the obtained results depends on the confidence in the software and the confidence in the accuracy of the predicted future state of the environment. In particular, if one has 100% confidence in the software, then confidence in the design depends on the accuracy of the predicted future states of the environment. Stochastic methods clearly reflect this (Schueller, 1991).

Classical design is a passive design technique.

Active Design

In active design, one initially uses passive design with a predicted average future state of the product's environment (i.e., the nominal environmental state) and then manufactures the product by equipping it with appropriate sensor(s), actuator(s), and an on-board processor. Deviations from the nominal state of the product are detected by the sensor(s) and eliminated in real time by the actuator(s) under the control of the software running on the on-board processor (Utku, 1998).

This is similar to, for example, designing a dam with classical design methodology using a predetermined stored water level (representing a predicted average future state of the environment), but constructing the dam with a water level sensor and a sluice-gate/gate-drive that are under the control of a microprocessor. During the design life of the dam, if and when the in-flow raises the water level beyond the predetermined level, the gate opens just enough to prevent water accumulation beyond the predetermined level. With the help of the sensor, the microprocessor at regular intervals measures the deviation from the predetermined level and activates the gate drive when the deviation becomes unacceptably large. This is a very simple example of the *sense-process-act cycle* of adaptive design. This process cycle needs to be repeated at a sufficiently high frequency throughout the design life of the dam. Assuming that one has 100% confidence in the operations of the sensor, the gate drive and the microprocessor, the designer does not need all the predicted future hydrographs related to the watershed of the dam for the design.

As a second example of adaptive design, consider a building with, say, a 50-year design life that is to be built to withstand up to magnitude six earthquakes in an area where stronger earthquakes can be expected. The building may be designed by using classical design methodology to function up to magnitude six earthquakes. For stronger than magnitude six earthquakes, with sensor output, the configuration may be altered in real time by changing the physical connection between the building and its foundations.

Adaptive design is an active design technique.

Role of Engineering Sciences and Mathematics

As discussed earlier, a civil engineering product must fulfill its function throughout its design life, i.e., the product should remain within an acceptably close neighborhood of its nominal state at all times. The design process ensures that this happens.

The state of a product can be expressed by a list of measurements of its important attributes. For example, for a railroad bridge truss, the list of forces in the bars and the displacement components of the nodes, that is, an n-tuple, may express its state. The state changes as the loading environment of the bridge changes. Because of the natural environment and live loads are dynamic, the loading environment of the truss changes with time as does the state of the truss. The loci of points in n-space representing states of the product at successive time instants during its design life is a curve which is the product's trajectory in state space (n-space). The spread in the mechanical properties of truss material and the constraints based on operational conditions define a neighborhood of acceptable designs around a trajectory point. The state-space trajectory for a properly designed truss is inside the neighborhood of acceptable designs. By choosing appropriate material and assigning appropriate values to the free-design parameters, with knowledge of loading environment throughout the design life, a civil engineer can complete the design of the railroad bridge truss, provided he knows how to compute the state of the truss corresponding to a given loading. The civil engineer learns how to do this by studying mathematics and engineering sciences (such as mechanics, strength of materials, and theory of structures). Without engineering sciences and mathematics, rational design of engineering products is not possible.

The state of a civil engineering product may require a description using many more components implied by the railroad truss example above. Considering that civil engineering products may involve chemicals, nuclear materials, soils, rocks, water, air etc., at different velocities, pressures, and temperatures, the wealth of valuable information that may be provided by engineering sciences is indeed very impressive. The engineering sciences are, no doubt, the essence of the technological advancements of today, and of tomorrow. No chances can be taken in transferring these to future generations.

Knowledge of the state space trajectory of a product requires two things: (a) knowledge of the environment affecting the state of the product during the design life, and (b) ability to compute the state of the product corresponding to a given environmental state. In the previous section, we have already noted that knowledge of the environmental states during the design life of a product requires prediction because the design life of the product still remains in the future at the time the engineer designs the product.

In this section we have indicated that, using mathematics and engineering sciences, the product's state corresponding to a given environmental state can be computed. This point requires further elaboration.

Because the computation of the state of the product corresponding to a given environmental state will have to be repeated for many time points in the design life, such computation has to be performed efficiently. Where the product's behavior permits, it is better to compute the change in product's nominal state due to the change in the environment corresponding to the product's nominal state. From the perspective of the product, the change in the environmental state may be designated an *excitation*, and the corresponding change in the product's state may be designated the *response*. The problem of computation, then, may be restated as: "given an excitation find the corresponding response". If the mathematical relations between excitation and response, i.e., the *excitation-response relations* are known, then, using appropriate mathematical procedures, the response to a given excitation may be computed. Excitation-response relations are studied in engineering sciences and the underlying mathematical techniques are studied in mathematics.

Sciences try to understand the universe around us. Scientists relentlessly observe the universe, directly and indirectly at all scales, and when possible, record their observations quantitatively. Scientists then study such data to discern patterns. Such patterns then lead to the discovery of natural laws like Newton's laws, Maxwell's electromagnetic theory etc. Because the number of scientists is finite but the phenomena that may be studied are infinite, engineering sciences breach the gap by striving to express, sometimes perhaps in a phenomenological way, principles in a form akin to natural laws. Mathematics and engineering sciences show us that we may express all such laws alternately as excitation-response relations. Our knowledge of an object may exist at varying scales of sophistication, from very little to very much. When we know the excitation-response relations underlying the object, then we know enough regarding the entity to the extent that we may be able to control the object to our advantage. Over the centuries, engineers accumulated knowledge sufficient to enable them to discover very powerful excitation-response relations in their domain of study.[16]

[16] Compared to engineers, other professionals such as medical doctors, economists, politicians have a depressingly low capability in connection with excitation-response relations in their respective domains, yielding inefficiencies in their professional performances.

Considering incremental changes, most excitation-response relations are linear in quantities representing the incremental response (i.e., the incremental state variables) However, excitation-response relations are rarely linear in response quantities when non-incremental changes are considered. This situation creates insurmountable difficulties in passive design, because in order to compute the state of a product at a specific point during its design life, we have to predict not only the state of the environment at that point in time, but also the entire history of the environmental state leading up to that point. However, in active design, the prediction of environmental states and their histories are not required. An active-design product will react almost immediately to an incremental change in the environment using its own means. In order to accomplish this, the active-design product utilizes the incremental excitation-response relations to determine how much of its own means need to be activated in order to compensate for the deviation from its nominal state that point in time. The computation necessary for this is performed in the onboard microprocessor using the measured deviation and the control law, i.e., the relation between the controls and the sensor output representing the deviation. It is important to note that the sensors measure the changes in the product's nominal state, not necessarily the changes in its environment. When the state is described with a single variable, the control law can be determined heuristically or experimentally. However, when the description of state requires many variables, the multi variable control law should be mathematically derived from the underlying incremental excitation-response relations that are specialized for the product (Utku, 2000).

Design Implementation

The product can be manufactured after its design is completed. "Manufacturing" for civil engineering products means construction. Depending upon the complexity and the total cost of the product, the production may take a considerable period of time. The Ataturk Dam on the Euphrates River took more than a decade to complete. Construction on the Three-Gorges Dam on the Yangtze River began in the late 1990's, and the project is not scheduled for completion before 2010. The construction of the dams under the control of the Tennessee Valley Authority in the United States lasted for decades. The English Channel Tunnel (i.e., the Chunnel) likewise took more than a decade for completion.

The production time for civil engineering products also depends on the sophistication of the tools made available by technology at the time of construction. The Sivas-Erzurum Railroad in Turkey was built using mules, hand-tools and surveyor-levels (Lectures on the Elements of Construction, Prof. Ali Fuat Berkman, 1951). On the other hand, the Chunnel was built by using enormous and powerful rock-carving machines and precision instruments incorporating lasers. One rule of thumb in estimating how long construction of a civil-engineering product will take is to divide the approximate total mechanical energy needed for construction of the product by the approximate total power used by devices employed in constructing the product.

Modern technology has made available tools with high power outputs for construction. Although high-powered machinery and energy are expensive, the use of such equipment in construction streamlines operations and enables cuts in construction time and cost. The returns from the huge capital invested in these very expensive civil engineering products do not begin until the manufacturing process is completed. This fact is probably the most effective motivation for finishing a project in time through proper planning and dedicated efforts.

The long manufacturing period for a complex product may be further lengthened due to external physical and social pressures. The completion of the construction of the Istanbul-Ankara freeway was delayed due to earthquakes in 1999 and 2000 on the North Anatolian Fault. The Baku-Tiblisi-Ceyhan pipeline construction project, which is to reduce petroleum tanker traffic through the Turkish straits when completed, will reduce the risk of an environmental disaster involving petroleum tankers that could cause considerable damage to Istanbul and its more than ten million inhabitants. This on-going project has been delayed because of the period of time it took for political leaders of other countries, which rely on the transportation of fossil fuel from Central Asia to understand the value of the environment and human life in areas currently traversed by the petroleum tankers.

The construction of civil engineering products may require long time spans and very large capital investments. Therefore the efficient development of a design into a product requires the cooperation of many disciplines and advanced technology.

Maintenance

Periodic maintenance of a product may be required for it to carry out its function without degradation throughout its design life. Ad hoc maintenance may also be required if the product experiences loading not considered properly during its design. In essence, maintenance is performed either to prevent or to eliminate deterioration in the proper functioning of the product. If one is prepared to accept a sharp increase in cost, it may be possible to produce a product that requires no maintenance throughout its design life. However, the economical realities of the present time require “maintenance” as another tool to maintain the trajectory of the product in state space within an acceptably close neighborhood of its nominal state.

In periodic maintenance, maintenance is performed at predetermined times, regardless of any apparent deterioration in the product’s function at the predetermined times. In ad hoc maintenance, maintenance is performed in response to an observed deterioration in the function of the product. In the former the passage of time, whereas in the latter, changes in the product’s performance, must be monitored. As the number and the complexity of products increase, the tasks required to carry out maintenance may rapidly fall outside the average performance limits of human beings. When this happens, one may use sensors and processors to detect abnormalities (and time) and activate maintenance procedures, i.e., one may employ a virtual *sense-process-act* cycle.

A civil engineering product – that is designed with passive design methodologies may be considered to be a semi-adaptive product when equipped with sensors and an on-board processor that monitor the passage of time or deterioration in the product’s performance. The product would be considered to be an adaptive product if the maintenance operations were carried out by robots hardwired to the product, instead of human beings.

At the end of the design life of a civil engineering product, it may, depending upon prevailing economical considerations, be: (a) kept functioning until the maintenance costs become unbearable; (b) abandoned to deteriorate until its remnants become too harmful for the population or nature; or (c) removed in its entirety. All cost optimization analyses for civil engineering products should include the cost of removing the product. Products like the nuclear power plants of Three Miles Island and Chernobyl would likely not have been produced or would have been designed differently if removal costs were taken into account during the cost analyses. Three Miles Island and Chernobyl disasters and other recent ones educated the engineers to be much more careful with their designs.

Trends

In any human enterprise, an awareness of the trends in the fields interfacing with the enterprise is necessary for efficient operations and professional survival. The civil-engineering enterprise is no exception. As discussed earlier, the civil-engineering enterprise intends to construct civil engineering products to meet the basic needs of societies in the physical world with minimum damage to nature and people. These products, which provide an interface between humans and nature, require that their designer be aware of trends in nature, as well as in societies and their technologies. What are these trends? I will now briefly discuss these.

The most important trend is in the number of additional people that will share the resources of the planet with each passing year. This quantity continues to increase. At the present rate, the current six billion populations of the earth will double itself in a few decades. In spite of the technological breakthroughs, unless our attitudes towards living together change collectively, and unless we show greater respect to the operations of international organizations, such as the United Nations, I, in my role as a civil engineer, believe that it will be very difficult to maintain basic human rights and the world order that all nations are trying to implement. Old attitudes that tend to increase the rift between the hemispheres and between the rich and the poor must change.

Because of the technological breakthroughs of the last half-century, the world is now viewed as being much smaller than before. People, goods, and ideas can now move between any two points of the world much more freely and economically. This, in turn, highlights the uneven distribution of civil engineering products across the globe. I believe, through international cooperation, good will, and human intelligence, the competition between nations will redirect itself to mutually more beneficial grounds in which belief in the human race and its habitat supercedes all other concerns. One indispensable result of such a redirection will likely be the construction of more civil engineering products in a way that eliminates their uneven distribution across the globe.

Since the Second World War, the dominant paradigm has been one in which the world is assumed to be scarcely populated and internally detached and in which resources are assumed to be infinite and the powers of recuperation of nature are assumed to be immense. Under this paradigm, industrial output has increased unchecked to satisfy the demands of an increasing population of individuals. This has resulted in the unhealthy environment of our time, as well as misguided industrial development and a skewed distribution of wealth. However, our concerns over these trends have led us to measure these using the tools of modern technology and extrapolate the measured data to predict the future that may result if we refuse to change our ways.

The world, which is already over populated, has serious global problems. We strive to elevate the quality of life of many people up to a basic minimum, but it appears that most of us do not agree on what that basic minimum should be.[17] To me, as a civil engineer, the basic minimum

[17] Is it a detached home, or an apartment in a skyscraper? Is it urban sprawl or is it new Manhattans? Is it transportation with a two-ton gas-guzzler, or with foot or bike? Is it a beef-steak, or bread and cheese? Is it education in the dominant language of the country or is it education in one's mother's tongue? Is it providing job to

includes clean air, clean water, a clean and less crowded environment, safe housing, and reliable shared-facilities of the society. These are things within the domain of civil engineering.

A quick look at the state of affairs regarding these basic minima throughout the world indicates that civil engineers must work much harder in (a) educating people about these basic minima, and (2) providing them to the population. Considering the growing resource-input and product-output of industry, with every passing day, industrial pollution is spreading unhindered in an effectively smaller world and the world is becoming more impotent in its ability to recover from the degradation caused by industrial pollutants. The development of new technologies for a cleaner environment and new regulations to control industry are already on the agendas of many countries that are seriously concerned about the future of the habitat of human beings.

Technological breakthroughs in the last century have resulted in engineering products that are too complex for people to manage. The range of the physical, chemical, physiological, and psychological parameters required for the proper functioning of human beings is too limited for the safe operation of the complex public facilities and products that are in use today and that will be used tomorrow. Thus, human beings need to automate the features associated with the safety of complex facilities and products to a much greater extent than present currently. The basic components of such automation, i.e., sensors, actuators, on-board processors, powerful communications technologies and training in the modern control theory necessary to properly use these components, are now available to help creative engineers in implementing mechanisms for the safer operation of public facilities and products. The civil engineer of tomorrow will have to work efficiently within an interdisciplinary team of scientists, engineers, and many other professionals.

Earlier, I stated that the design of civil engineering products requires the prediction of future states of the environment. Because of advances in sensor technology and other supporting technologies, civil engineers can now quantitatively observe the environment without damaging it, in a continuous and reliable manner and with higher precision, at a much greater sampling frequency than before. Because of advances in computer technology, civil engineers can process large streams of observational data quickly and mathematically to obtain more precise predictions of the environmental states for times further in the future. As a consequence, the civil engineering products of the future will have longer design lives, higher reliability, and will require less initial investment.

Civil engineers will be able use many commercially available modern sensors under the control of on-board processors more creatively to schedule the maintenance operations and crews for the safer operations of the civil engineering products. A civil engineering product properly equipped with modern sensors may also function as a reliable observer of its environmental domain.

---

any person willing to work, or is it to have a pool of unemployed waiting for various business sectors to have openings? Is it to raise professionals to make wars, or is it to raise professionals to ensure peace? Is it to make clones of people, or is it to properly raise the ones already born and suffering? Is it to burn fossil fuel, or to obtain energy from an alternative source? Is it my life style, or yours, or that of Huseyin Cimen who is a laborer-farmer from Sakiz village of Dursunbey, Balikesir? Is it entertainment or is it work? Is it life in the country or life in the city? Is it muscle or is it mind? Is it to tell the young that the life is chaos, or tell them that the life is order? Is it a media not finding these interesting to discuss, or is it a media trying to educate public in all these and more as they pass the news and carry the advertisements?

Because of advances in communication technologies, sensor data from civil engineering products can be quickly directed to centers having powerful computing facilities for not only better coordination of the maintenance of civil engineering products, but for also support of the global efforts to better study our environment, our planet, and consequently, our future.

The current trend of using photons instead of electrons will no doubt further decrease the sizes and increase processing speeds of microprocessors. As a result, civil engineers will have faster simulation and control software for use in designing their products. The design time also the response time will be shorter, and products will be better and less costly.

Nature uses active design heavily in its creations. The human body contains millions of feedback control systems all using the *sense-process-act* cycle with different sampling frequencies that keep the respective controlled entities in their desired states. Through advances in sensor, microprocessor and actuator technologies, as well as with a better understanding of the underlying control theory, civil engineers of the future will find more opportunities in employing active design technology in their products.

Acknowledgement
The author gratefully acknowledges the help of his son, Sinan Utku, in editing this manuscript.

References

Norris, C.H., J. B. Wilbur, and S. Utku (1976). Elementary Structural Analysis, 3rd ed., McGraw-Hill Book Company, New York.

Schueller, Gerhart I. (1991), editor, Structural Dynamics, Recent Advances, Springer – Verlag, New York.

Utku, Senol (1998). Theory of Adaptive Structures, Incorporating Intelligence into Engineered Products, CRC Press, New York.

Utku, Senol (2000). Incorporating Intelligence into Engineered Products: Adaptive Structures, Special Issue on Adaptive Structures (A. Sierig guest editor), International Journal of Computer Applications in Technology (journal established and operating under the auspices of UNESCO), vol. 13, no 1-2, pp.1-9.

Senol Utku obtained his D.Sc. (`'60) and S.M. ('59) degrees in the area of Structural Mechanics from MIT , and his Dipl. Ing. degree in Civil Engineering ('54) from Istanbul Technical University (ITU). He came to the United States with a Fulbrignt scholarship in 1957. After ten years of research work at IBM and JPL in the area of computational mechanics, he returned to his teaching in 1970 by joining Duke University's Civil Engineering and Computer Science Departments. His teaching career started at ITU in 1955 and continued at MIT, Middle East Technical University, University of Southern California, University of Washington, and Bogazici University He became a professor emeritus at ITU in 1994 and at Duke University in 2002. He strives to bring together the cultures and the disciplines that formed his mind.

The Engineer: Professional or Business Practitioner?

By Donald Christiansen

Reprinted with Permission from IEEE-USA, News & Views, June 2002

Imagine yourself in this situation: You are part of a project team to get a newly developed electronic device into shape for full-scale production. It is a solid-state device with a significant new function. It could enable any customer who designed it into its line of consumer products to gain a considerable advantage over its competition. A pilot production line has been set up, but to your team's consternation, yields are negligible to non-existent. Your company's marketers had alerted its best customer to the project and provided engineering samples. The customer has redesigned a major product line around the new device, and it hopes to obtain exclusive rights to purchase it for a period of one year. Its marketing people are poised to roll out a major television and print advertising campaign.

Your management has elected not to inform the customer about the low yield problem. In just a few days, a high-level group of engineers from the customer is scheduled to visit. Your team knows the visitors expect to view the production line. What would you advise management to do? Cancel or postpone the visit? Tell the customer about the problem?

Here's what actually happened. The visit came off as scheduled. After a carefully timed technical presentation in the conference room, the visitors were led to the production area to view the various steps in the production process. Then, to a predetermined timetable, they reached the final test station, where an operator carefully and deliberately put one after another of the devices through their paces. All passed with flying colors. When she completed the test of the sixth device, she excused herself; it was the lunch break. As she made her way to the cafeteria, the visitors were invited to the executive dining room. None were told that the six devices they had witnessed being tested were the only ones available that adequately met all specifications. Each had been pretested, and the operator had waited patiently for the arrival of the visitors, performed the tests, and departed on cue.

Duly impressed, the visitors left with full intentions of going forward with their plans. They did so, and the device manufacturer was able to debug the production processes, increase yield, and ultimately put the new device into full-scale production without causing any delay in the customer's product introduction.

Since I once witnessed an incident very similar to this, I have used it from time to time and with variations as a case history for discussion by young engineers and engineering students. It always provokes comment. For example, why did management keep the yield problem from its customer? Did that action (or inaction) represent an ethical lapse? Should the engineers on the project team have objected to the secrecy, or at least to the test charade?

Many employed engineers concluded that the incident was not unusual. They thought it more of a business decision than an engineering decision, although they conceded that the engineers may well have played a role in reassuring management by projecting (or even promising) timely solutions to the yield problem. Some found it humorous, a trivial deception worthy of any competent poker player; a business coup of sorts.

Students exposed to the case study were more likely to believe that the customer (especially a favored customer) should have been kept fully informed. Engineers who had faced similar dilemmas also favored disclosing the problem to the customer. After all, they reasoned, the supplier's engineers and the customer's engineers had in all likelihood worked as partners in earlier phases of the development; why not continue to do so? Managers did not necessarily agree; the supplier's problems were internal and to reveal them could deflate the company's good reputation.

This case study is representative of the dilemma faced by the employed engineer. He or she is both a professional and an employee, thus owing allegiance to both the profession and his or her employer. As the engineer assumes managerial responsibilities, the plot thickens. Engineers are by nature and training disposed to honesty and openness, gaining new knowledge and bartering information. They keep corporate lawyers busy defining what information is proprietary, protecting patent positions, and limiting what can be revealed to the outside world. And managers have the daunting task of allowing engineers selective autonomy on technical matters, while encouraging them to broaden their understanding of business factors.

Edwin Layton, a professor of mechanical engineering at the University of Minnesota, in his classic book *The Revolt of the Engineers,* defined the situation succinctly. "The engineer is both a scientist and a businessman. Engineering is a scientific profession, yet the test of the engineer's work lies not in the laboratory, but in the marketplace. The claims of science and business have pulled the engineer, at times, in opposing directions."

The pull that Layton speaks of is seen in many different ways, none so dramatic, perhaps, as that experienced by Morton Thiokol's vice president of engineering, who became a pivotal player in the Space Shuttle Challenger disaster. Thiokol was the supplier to NASA of the booster rockets for the Challenger spacecraft. Concerned about recommending a launch in extremely cold weather that could exacerbate a known failure mechanism in the boosters, the vice president called a meeting of his staff. Together they concluded the launch should be postponed. Later in the day, at a meeting of his management peers, he was asked by his boss to think like a manager rather than an engineer. He then changed his mind, voting for the launch. It went off on schedule. An O-ring in the booster failed. Challenger exploded. All aboard were lost.

What caused the engineering vice president to change his mind? In the meeting with his engineers, wearing his engineer's hat, did he think the consequences of a Shuttle loss would be unacceptable, regardless of any benefits that might be gained if the launch were successful? Then, in the meeting with his boss, donning his manager's hat, did he think the risk of a Shuttle loss was outweighed by the potential benefits of a successful on-time launch (accolades to NASA, an increase in its budget, support for future space programs, more business for Thiokol)? In fairness, there were many factors leading to the disaster, not the least of which was the weakness in the O-rings, long known to engineers and managers of both Thiokol and NASA. But the critical factor seemed inarguable to most post-accident analysts — the engineering vice president had switched his vote when he "thought like a manager."

One of the byproducts that scholars see as engineers move into management is a *de facto* loss of expert knowledge, and a concentration on the exigencies of business. The engineer values knowledge and the manager initiative, loyalty, and team effort, they note.

Engineers interviewed as part of a study* of how engineers, engineering managers, and managers work together under normal conditions gave a broad range of comments, varying from "We operate by consensus" to "Technical questions get short-changed to make schedule," and "They'll [managers] sacrifice quality to get it out the door." A manager interviewed in the same study said "Engineers have high weight on technical issues. The problem is integrating technical recommendations into company interest. Cost. Marketing strategy. Change in technology. Etcetera. It's important that the engineer's recommendations get out beyond [his] immediate group. When he sees how his decision does not fit into the larger picture, he's likely to rethink it."

It seems to me necessary — and even beneficial, this perennial tug-of-war between perfectionist engineers and their managers, the latter more concerned with price and delivery demands of the marketplace. This contention, or collaboration, as the case may sometimes be, after all represents a check-and-balance system. However, danger signals may be that one party "wins" too frequently or that the engineers withdraw from the dialogue prematurely. An engineer who fails to make a convincing case for lack of trying cannot expect to shift the blame to his or her boss when something goes awry as a result. Nor should sensitivity of the engineer to the needs of the business require the abrogation of his or her principal responsibilities: quality, safety and the search for technical sophistication and superior design.

Resources

For more about the engineer-manager interface, see:

*Davis, M., *Thinking Like an Engineer*, Oxford University Press, 1998.

Layton, E., *The Revolt of the Engineers*, Case Western Reserve University Press, 1971; reprinted with a new introduction by the author, The Johns Hopkins University Press, 1986.

Pool, R., *Beyond Engineering*, Oxford University Press, 1997.

Vaughn, D., *The Challenger Launch Decision*, University of Chicago Press, 1996.

Vincenti, W. G., *What Engineers Know and How They Know It*, The Johns Hopkins University Press, 1990.

Acta Materialia 50(15) 2002

Acta Materialia 50(16) 2002

Acta Materialia 50(17) 2002

4205	Fatigue crack growth in a ti beta 21s/scs-6 composite	Liu J. Bowen P.
4219	Measurement of melt ejection velocities during laser drilling of steel, using a novel droplet stream interception technique	Voisey KT. Klocker T. Clyne TW.
4231	Dislocation reactions in zrn	Li P. Howe JM.
4241	Critical thickness for cracking of pb(zr0.53ti0.47)o-3 thin films deposited on pt/ti/si(100) substrates	Zhao MH. Fu R. Lu D. Zhang TY.
4255	Ni4ti3-precipitation during aging of niti shape memory alloys and its influence on martensitic phase transformations	Khalil-Allafi J. Dlouhy A. Eggeler G.
4275	The effect of scandium on the microstructure, mechanical properties and weldability of a cast al-mg alloy	Lathabai S. Lloyd PG.
4293	High-temperature creep behavior of tic particulate reinforced ti-6al-4v alloy composite	Ma ZY. Mishra RS. Tjong SC.
4303	Monte carlo simulation of grain boundary segregation and decohesion in nial	Xie X. Mishin Y.
4315	Rupture time analyses of the sn-3.5ag solder alloys containing cu or bi	Yu J. Joo DK. Shin SW.
4325	Compressive creep of mullite containing y2o3	de Arellano-Lopez AR. Melendez-Martinez JJ. Cruse TA. Koritala RE. Routbort JL. Goretta KC.
4339	Crystallographic aspects of the early stages of recrystallisation in brass-type shear bands	Paul H. Driver JH. Maurice C. Jasienski Z.
4357	Anomalous thermal stability of nd-fe-co-al bulk metallic glass	Wei BC. Loser W. Xia L. Roth S. Pan M. Wang WH. Eckert J.
4369	Combined effects of silica filler and its interface in epoxy resin	Wang HY. Bai YL. Liu S. Wu JL. Wong CP.
4379	On the dependence of in-grain subdivision and deformation texture of aluminum on grain interaction	Raabe D. Zhao Z. Mao W.
4395	The effect of the microscale distribution of boron on the yield strength of c-mn steels subjected to neutron irradiation	Jones RB. Younes CM. Heard PJ. Wild RK. Flewitt PEJ.
4419	Superplastic deformation behaviour of friction stir processed 7075al alloy	Ma ZY. Mishra RS. Mahoney MW.
4431	Microstructure evolution in pearlitic steels during wire drawing	Zelin M.

Acta Mechanica 158(1-2) 2002

1	Vibration of translating cables	Wolfe P.
15	Mechanical response of a water-saturated core sample under opposite diametrical loadings	Mikami Y. Kurashige M. Imai K.
33	The theory of general and ideal plastic deformations of tresca solids	Richmond O. Alexandrov S.
43	A three-phase circular inhomogeneity with imperfect interface under thermomechanical loadings in plane elasticity	Sudak LJ. Mioduchowski A.
57	Study of vibration suppression in discrete domain	Dingyue C. Xia L. Hongsheng C. Hui X. Jianjia D.
67	Two circular inclusions with inhomogeneous interfaces interacting with a circular eshelby inclusion in anti-plane shear	Wang X. Shen YP.
85	Transient motion due to a moving dislocation in a general anisotropic solid	Wu KC.
97	Constitutive relations of linear elastic materials under various internal constraints	Zheng QS.
105	The effect of wall absorption on dispersion in annular flows	Sarkar A. Jayaraman G.
121	Slip flow past a stretching surface	Andersson HI.

AIAA Journal 40(10) 2002

1921	Astrobiology - exploring the living universe	Morrison D.
1926	Development and characterization of hartmann tube fluidic actuators for high-speed flow control	Kastner J. Samimy M.
1935	Large eddy simulation of shock/boundary-layer interaction	Garnier E. Sagaut P. Deville M.
1945	Numerical method for vorticity confinement in compressible flow	Hu GC. Grossman B. Steinhoff J.
1954	Edge-based multigrid and preconditioning for hybrid grids	Moinier P. Muller JD. Giles MB.
1961	Computation of subsonic inviscid flow past a cone using high-order schemes	Kim JW. Morris PJ.
1969	Anisotropic solution-adaptive for turbulent viscous cartesian grid method flow simulation	Wang ZJ. Chen RF.
1979	Turbulence in plasma-induced hypersonic drag reduction	Appartaim R. Mezonlin ED. Johnson JA.
1984	Modeling rotating and swirling turbulent flows: a perpetual challenge	Jakirlic S. Hanjalic K. Tropea C.
1997	Fast convergence of viscous airfoil design problems	Dadone A. Grossman B.
2006	Rarefied gas flow into vacuum through thin orifice: influence of boundary conditions	Sharipov F.
2009	Forward-running detonation drivers for high-enthalpy shock tunnels	Jiang ZL. Zhao W. Wang C. Takayama K.

Applied Mathematical Modelling 26(9) 2002

Applied Mathematical Modelling 26(10) 2002

Applied Mathematical Modelling 26(11) 2002

Applied Mathematics & Mechanics 23(7) 2002

773	Two-grid error estimates for the stream function form of navier-stokes equations	Ren CF. Ma YC.
783	A nonlinear galerkin/petrov-least squares mixed element method for the stationary navier-stokes equations	Luo ZD. Zhu J. Wang HJ.
794	Rossby inertia gravity solitary wave and the remote correlation between the east- and the west-pacific subtropical high	Zhang R. Wang JG. Yu ZH. Jiang QR.
804	Extended self similarity of passive scalar in rayleigh-benard convection flow based on wavelet transform	Fu Q. Xia KQ.
811	Squeeze flow of a power-law fluid between two, rigid spheres with wall slip	Huang WB. Xu Y. Lian GP. Li HY.
819	Time-shifting correcting method of phase difference on discrete spectrum	Ding K. Luo JK. Xie M.
828	Modules over double crossproducts of skew-hopf pairs	Pan QN. Hao ZD.
835	The multi symplectic algorithm for "good" boussinesq equation	Zeng WP. Huang LY. Qin MZ.
842	A stress vector-based constitutive model for cohesionless soil (ii) - application	Shi YY. Xie DY. Bai L.
854	Positive solutions to a singular second order three-point boundary value problem	Qu WB. Zhang ZX. Wu JD.

Archive for Rational Mechanics & Analysis 164(2) 2002

103	On pitteri neighborhoods centered at hexagonal close-packed configurations	Ericksen JL.
133	Theory of extended solutions for fast-diffusion equations in optimal classes of data. radiation from singularities	Chasseigne E. Vazquez JL.

Archive for Rational Mechanics & Analysis 164(3) 2002

189	A sharp upper bound for the torsional rigidity of rods by means of web functions	Crasta G. Fragala I. Gazzola F.
213	Regularity results for stationary electro-rheological fluids	Acerbi E. Mingione G.
261	Solutions of euler-poisson equations for gaseous stars	Deng YB. Liu TP. Yang T. Yao ZA.

Communications on Pure & Applied Mathematics 55(11) 2002

1365	Dynamics of singularity surfaces for compressible, viscous flows in two space dimensions	Hoff D.
1408	A reduced theory for thin-film micromagnetics	Desimone A. Kohn RV. Muller S. Otto F.
1461	A theorem on geometric rigidity and the derivation of nonlinear plate theory from three-dimensional elasticity	Friesecke G. James RD. Muller S.

Composites - Part A: Applied Science & Manufacturing 33(8) 2002

1033	Carbon-nanofibre-reinforced poly(ether ether ketone) composites	Sandler J. Werner P. Shaffer MSP. Demchuk V. Altstadt V. Windle AH.
1041	Thermal and electrical properties of magnetite filled polymers	Weidenfeller B. Hofer M. Schilling F.
1055	Low-velocity impact-induced damage of continuous fiber-reinforced composite laminates. part 1. an fem numerical model	Li CF. Hu N. Yin YJ. Sekine H. Fukunaga H.
1063	Low-velocity impact-induced damage of continuous fiber-reinforced composite laminates. part ii. verification and numerical investigation	Li CF. Hu N. Cheng JG. Fukunaga H. Sekine H.
1073	Prediction of the yam trajectories on complex braided preforms	Kessels JFA. Akkerman R.
1083	Engineering and characterisation of the interface in flax fibre/polypropylene composite materials. part i. development and investigation of surface treatments	Zafeiropoulos NE. Williams DR. Baillie CA. Matthews FL.
1095	Non-orthogonal constitutive equation for woven fabric reinforced thermoplastic composites	Yu WR. Pourboghrat F. Chung K. Zampaloni M. Kang TJ.
1107	Effects of vacuum, mold temperature and cooling rate on mechanical properties of press consolidated glass fiber/pet composite	Lee DJ. Shin IJ.
1115	Apparent coefficient of thermal expansion and residual stresses in multilayer capacitors	Hsueh CH. Ferber MK.
1123	Forming performance and biodegradability of woodfibre-biopol (tm) composites	Peterson S. Jayaraman K. Bhattacharyya D.
1135	Tensile behaviour of squeeze cast am100 magnesium alloy and its al2o3 fibre reinforced composites	Jayalakshmi S. Kailas SV. Seshan S.
1141	Cell-wall hardness and young's modulus of melamine-modified spruce wood by nano-indentation	Gindl W. Gupta HS.

Computational Mechanics 29(3) 2002

Computer Methods in Applied Mechanics & Engineering 191(39-40) 2002

Computer Methods in Applied Mechanics & Engineering 191(41-42) 2002

Computer Methods in Applied Mechanics & Engineering 191(43) 2002

Computer Methods in Applied Mechanics & Engineering 191(44) 2002

Computers & Fluids 32(1) 2003

Computers & Structures 80(18-19) 2002

Computers & Structures 80(20-21) 2002

Computers & Structures 80(22) 2002

Earthquake Engineering & Structural Dynamics 31(11) 2002

Engineering Fracture Mechanics 69(17) 2002

Engineering Structures 24(11) 2002

Engineering Structures 24(12) 2002

European Journal of Mechanics A-Solids 21(5) 2002

Experiments in Fluids 33(3) 2002

Finite Elements in Analysis & Design 38(12) 2002

Flow, Turbulence & Combustion 68(2) 2002

International Journal for Numerical & Analytical Methods in Geomechanics 26(12) 2002

International Journal for Numerical Methods in Engineering 55(5) 2002

International Journal for Numerical Methods in Engineering 55(6) 2002

International Journal for Numerical Methods in Engineering 55(7) 2002

International Journal for Numerical Methods in Engineering 55(8) 2002

International Journal for Numerical Methods in Engineering 55(9) 2002

International Journal for Numerical Methods in Fluids 40(1-2) 2002

International Journal for Numerical Methods in Fluids 40(3-4) 2002

International Journal for Numerical Methods in Fluids 40(5) 2002

International Journal for Numerical Methods in Fluids 40(6) 2002

International Journal for Numerical Methods in Fluids 40(7) 2002

International Journal of Engineering Science 40(14) 2002

1611	Heat equation in a perforated composite plate: influence of a coating	Taghite MB. Taous K. Maurice G.
1647	Load transfer at imperfect interfaces - dislocation-like model	Yu HY. Wei YN. Chiang FP.

International Journal of Engineering Science 40(15) 2002

1665	A screw dislocation in a piezoelectric bi-material wedge	Chen BJ. Xiao ZM. Liew KM.
1687	On conservation laws in generalized dynamic thermoelasticity	Koureas T. Charalambopoulos A. Kalpakides VK.
1697	Fracture of a piezoelectric material layer bonded by two elastic layers	Wang BL. Mai YW.
1729	Axisymmetric crack problem of a thick-walled cylinder with cladding	Birinci A.
1751	Closed-form solution for the size of plastic zone in an edge-cracked strip	Wu XF. Dzenis YA.
1761	Transient internal crack problem for a nonhomogeneous orthotropic strip (mode i)	Chen J. Liu ZX. Zou ZZ.
1775	Fundamental solutions for the generalised plane strain theory	Kotousov A. Wang CH.

International Journal of Engineering Science 40(16) 2002

1791	On solutions of some non-linear differential equations arising in third grade fluid flows	Vajravelu K. Cannon JR. Rollins D. Leto J.
1807	A continuum theory of porous media saturated by multiple immiscible fluids: i. linear poroelasticity	Wei CF. Muraleetharan KK.
1835	A continuum theory of porous media saturated by multiple immiscible fluids: ii. lagrangian description and variational structure	Wei CF. Muraleetharan KK.
1855	On the ucar prototype model	Lonngren KE. Bai EW.
1859	On the theory of heat conduction in micromorphic continua	Iesan D.
1879	On kaplun limits and the generalized boundary layer theory	Cruz DOA.

International Journal of Engineering Science 40(17) 2002

1897	Modulation of nonlinear waves in a viscous fluid contained in a tapered elastic tube	Demiray H.
1919	A nonlinear dynamical systems framework for structural diagnosis and prognosis	Adams DE. Nataraju M.
1943	On the boundary integral formulation of thermo-viscoelasticity theory	El-Karamany AS. Ezzat MA.
1957	A generalized variational model of magneto-thermo-elasticity for nonlinearly magnetized ferroelastic bodies	Wang XZ. Zhou YH. Zheng XJ.
1975	The disturbance of a plane dyadic wave by a small spherical cavity	Dassios G. Karveli K. Kattis SE. Kathreptas N.

International Journal of Fatigue 24(11) 2002

1109	A neural network approach to the simulation of load histories by considering the influence of a sequence of rainflow load cycles	Klemenc J. Fajdiga M.
1127	Influence of shot peening on bending tooth fatigue limit of case hardened gears	Benedetti M. Fontanari V. Hohn BR. Oster P. Tobie T.
1137	Cycle distribution and fatigue damage under broad-band random loading	Tovo R.
1149	A single loading direction for fatigue life prediction and testing of handlebars for off-road bicycles	McKenna SP. Hill MR. Hull ML.
1159	High temperature fatigue crack growth in two metals under constant and variable amplitude loading	Mansson T. Skantz J. Nilsson F.
1169	Analysis of short fatigue crack growth in cast aluminum alloys	Ishihara S. McEvily AJ.
1175	A study of small crack growth in aluminum alloy 7075-t6	Donnelly E. Nelson D.
1191	Contact problem with partial slip for the inclined punch with rounded edges	Goryacheva IG. Murthy H. Farris TN.

International Journal of Fatigue 24(12) 2002

1205	Computational assessment of the influence of load ratio on fatigue crack growth in fibre-reinforced metal matrix composites	Rauchs G. Withers PJ.
1213	Mode ii stress intensity factors for central slant cracks with frictional surfaces in uniaxially compressed plates	Hammouda MMI. Fayed AS. Sallam HEM.
1223	Effect of various surface conditions on fretting fatigue behavior of ti-6al-4v	Hutson AL. Niinomi M. Nicholas T. Eylon D.
1235	Off-axis fatigue loading of steamed wood	Karenlampi PP. Tynjala P. Strom P.

International Journal of Fracture 116(1) 2002

International Journal of Fracture 116(2) 2002

International Journal of Fracture 116(3) 2002

International Journal of Heat & Mass Transfer 45(24) 2002

International Journal of Heat & Mass Transfer 45(25) 2002

International Journal of Heat & Mass Transfer 45(26) 2002

International Journal of Impact Engineering 27(10) 2002

International Journal of Mechanical Sciences 44(8) 2002

International Journal of Non-Linear Mechanics 38(1) 2003

International Journal of Non-Linear Mechanics — 38(2) 2003

133	Control of the rotational motion of the rigid body with the help of internal rotors using rodrigues-caley parameters	El gohary A. Askar SS.
143	The effect of tangential elasticity of the contact layer between stator and rotor in travelling wave ultrasonic motors	Storck H. Wallaschek J.
161	Spectral simulation and shock absorber identification	Schiehlen W. Hu B.
173	Implications of cubic physical/aerodynamic non-linearities on the character of the flutter instability boundary	Librescu L. Chiocchia G. Marzocca P.
201	Effect of matrix cracking in cross-ply ceramic matrix composite beams on their mechanical properties and natural frequencies	Birman V. Byrd LW.
213	Piecewise linear model for water column oscillator simulating reactor safety system	Yuichiro M. Haruki M.
225	Imperfection sensitivity of curved panels under combined compression and shear	Featherston CA.
239	A new approach to almost-sure asymptotic stability of stochastic systems of higher dimension	Huang ZL. Zhu WQ.
249	Application of vector-valued rational approximations to a class of non-linear oscillations	Wu BS. Zhong HX.
255	Fluid with internal wettability	Biguenet F.
267	Internal ring buckle arrestors for pipe-in-pipe systems	Olso E. Kyriakides S.
285	On the dynamics of cranes, or spherical pendula with moving supports (vol 37, pg 1211, 2002)	Ghigliazza RM. Holmes P.

International Journal of Plasticity — 18(10) 2002

1271	Microstructure consideration with plastic spin and multiple back-stresses for large strain problems in soils	Song CR. Voyiadjis GZ.
1291	A thermomechanical model with microstructure evolution for aluminium alloy casting processes	Celentano DJ.
1337	Compressive failure strengths and modes of woven s2-glass reinforced polyester due to quasi-static and dynamic loading	Khan AS. Colak OU. Centala P.
1359	Tinge and temperature dependent response and relaxation of a soft polymer	Khan AS. Lopez-Pamies O.
1373	Modeling the evolution of anisotropy in al-li alloys: application to al-li 2090-t8e41	Garmestani H. Kalidindi SR. Williams L. Bacaltchuk CM. Fountain C. Lee EW. Es-Said OS.
1395	A thermo-mechanical study of mode i, small-scale yielding crack-tip fields in glassy polymers [rumanian]	Basu S. Van der Giessen E.

International Journal of Plasticity — 18(11) 2002

1425	Special issue on: micromechanics of martensitic phase transformations	Levitas VI. Cherkaoui M.
1427	Mesomechanics of the alpha-epsilon transition in iron	Yano K. Horie Y.
1447	Impact induced propagation of phase transformation in a shape memory alloy rod	Bekker A. Jimenez-Victory JC. Popov P. Lagoudas DC.
1481	The initiation and growth of macroscopic martensite band in nano-grained niti microtube under tension	Li ZQ. Sun QP.
1499	Critical thought experiment to choose the driving force for interface propagation in inelastic materials	Levitas VI.
1527	Crystal-based simulations in transformation thermomechanics of shape memory alloys	Kitajima Y. Sato N. Tanaka K. Nagaki S.
1561	Control of intrinsic instability of superelastic deformation	Slutsker J. Roytburd AL.
1583	Computational simulation on deformation behavior of ct specimens of trip steel under mode i loading for evaluation of fracture toughness	Iwamoto T. Tsuta T.
1607	Superelastic behavior in tension-torsion of an initially-textured ti-ni shape-memory alloy	Thamburaja P. Anand L.
1619	Determination of the interaction energy in the martensitic state	Niclaeys C. Ben Zineb T. Arbab-Chirani S. Patoor E.

International Journal of Solids & Structures 39(17) 2002

International Journal of Solids & Structures 39(18) 2002

International Journal of Solids & Structures 39(19) 2002

International Journal of Solids & Structures 39(20) 2002

Inverse Problems in Engineering 10(5) 2002

Journal of Biomechanical Engineering 124(5) 2002

Journal of Biomechanics 35(10) 2002

Journal of Biomechanics 35(11) 2002

Journal of Composite Materials 36(19) 2002

Journal of Composite Materials 36(20) 2002

Journal of Computational Physics 181(2) 2002

Journal of Elasticity 66(1) 2002

Journal of Engineering Materials & Technology 124(4) 2002

Journal of Engineering Mathematics 43(2-4) 2002

Journal of Engineering Mathematics 44(1) 2002

Journal of Engineering Mechanics 128(10) 2002

Journal of Fluid Mechanics 466 2002

Journal of Fluid Mechanics 467 2002

Journal of Fluid Mechanics 468 2002

Journal of Fluids & Structures 16(5) 2002

Journal of Fluids & Structures 16(6) 2002

Journal of Intelligent Material Systems & Structures 13(1) 2002

Journal of Microelectromechanical Systems 11(5) 2002

Journal of Non-Newtonian Fluid Mechanics 106(2-3) 2002

Journal of Reinforced Plastics & Composites 21(14) 2002

Journal of Reinforced Plastics & Composites 21(15) 2002

Journal of Sound & Vibration 256(2) 2002

Journal of Sound & Vibration 256(3) 2002

Journal of Sound & Vibration 256(4) 2002

Journal of the Mechanics & Physics of Solids 50(11) 2002

Journal of Thermal Stresses 25(10) 2002

Journal of Thermal Stresses 25(11) 2002

Journal of Vibration & Acoustics 124(4) 2002

642	Application of dynamic fractional differentiation to the study of oscillating viscoelastic medium with cylindrical cavity	Ingman D. Suzdalnitsky J.
645	The analysis and control of longitudinal vibrations from wave viewpoint	Mei C.
649	A new finding on the dynamic stiffness matrices of asymmetric and axisymmetric shafts	Raffa FA. Vatta F.
653	New method for solution of response of nonlinear hysteretic system	Liu JL.
656	Torsional vibration of non-uniform shafts carrying an arbitrary number of rigid disks	Qiao H. Li QS. Li GQ.

JSME International Journal Series B-Fluids & Thermal Engineering 45(3) 2002

445	Special issue on international conference on power and energy system - foreword	Yamada T.
446	Modeling of the main component of the bottoming stage in an advanced cogeneration system on the operational planning	Tomizawa M. Takeshita K. Tsuri K. Amano Y. Akiba M. Hashizume T.
451	Simulation of co2 recovering closed gas turbine with ch4-o-2 firing	Ebara T. Iki N. Takahashi S. Hama J.
457	Ldv measurements of unsteady flow within a turbine rotor at low reynolds numbers	Matsunuma T. Abe H. Tsutsui Y.
465	Flow film boiling heat transfer in water and freon-113	Liu QS. Shiotsu M. Sakurai A.
473	A review of study on thermal energy transport system by synthesis and decomposition reactions of methanol	Liu QS. Yabe A. Kajiyama S. Fukuda K.
481	Performance of high temperature air combustion boiler with low nox emission	Kobayashi H. Ito Y. Tsuruta N. Yoshikawa K.
487	R and D on micro-pyrolyzer for solid wastes using high temperature steam and air	Wu W. Yoshikawa K.
492	Upgrading and life extension technologies for existing steam turbines	Sakuma A. Takahashi T. Fujiwara T. Fukuda M.
499	Structures and stability of lifted combustion zones in preheated oxidizer	Ruan JM. Kobayashi H. Niioka T. Abuliti A. Iida F.
506	Emission characteristics of nox and unburned carbon in fly ash of sub-bituminous coal combustion	Ikeda M. Kozai Y. Makino H.
512	Performance of sorbent particles for removal of cadmium in hot gas	Yoshiie R. Goto S. Nishimura M. Moritomi H.
518	A study on gasification reactivity of pressurized two-stage entrained flow coal gasifier	Hara S. Inumaru J. Ashizawa M. Ichikawa K.
523	Study on extra heavy oil gasification reaction process	Kidoguchi K. Hara S. Ashizawa M. Inumaru J.
530	A systematic analysis of the effect of air humidification to gas turbine systems	Takahashi T. Koda E. Mimaki T.
536	Remote monitoring life management system for gas turbines	Gotoh J. Hayasaka Y. Sakurai S. Ikeda H.
543	Long-term operating experience of mitsubishi advanced g-series gas turbine	Tsukagoshi K. Akita E. Fukuizumi Y. Watanabe K.
552	Development of new advanced low pressure end blades for high efficiency steam turbine	Watanabe E. Ohyama H. Kaneko Y. Miyawaki T. Tanaka Y.
559	Transient heat transfer for forced convection flow of helium gas	Liu QS. Fukuda K.
565	A new electrode-mesh tomograph for advanced studies on bubbly flow characteristics	Richter S. Aritomi M.
577	Evaluation method for core thermohydraulics during natural circulation in fast reactors - (numerical predictions of inter-wrapper flow)	Kamide H. Nagasawa K. Kimura N. Miyakoshi H.
586	Development of mitsubishi high thermal performance grid (cfd applicability for thermal hydraulic design)	Ikeda K. Hoshi M.
592	Study on convective mixing for thermal striping phenomena (experimental analyses on mixing process in parallel triple-jet and comparisons between numerical methods)	Kimura N. Nishimura M. Kamide H.
600	Simulation of two-phase flows and numerical evaluation of interfacial area	Watanabe T. Ebihara K.
607	Severe accident analysis code sampson improvement for impact project	Ujita H. Ikeda T. Naitoh M.
615	Manufacturing and handling techniques of the monolithic buffer material for hlw disposal	Awano T. Kanno T. Ueda H. Kimoto T.
621	Development of volume-reduction system for ion exchange resin using inductively coupled plasma	Fujisawa M. Katagiri G.
626	Hybrid probabilistic and possibilistic safety assessment: methodology and application	Kato K. Amano O. Ueda H. Ikeda T. Yoshida H. Takase H.
631	On the collapsing behavior of cavitation bubble clusters	Konno A. Kato H. Yamaguchi H. Maeda M.
638	Unstable cavitation behavior in a circular-cylindrical orifice flow	Sato K. Saito Y.
646	Observations of oscillating cavitation on a flat plate hydrofoil	Sato K. Tanada M. Monden S. Tsujimoto Y.
655	Inner structure of cloud cavity on a foil section	Kawanami Y. Kato H. Yamaguchi H. Maeda M. Nakasumi S.
662	Tip leakage vortex cavitation from the tip clearance of a single hydrofoil	Higashi S. Yoshida Y. Tsujimoto Y.
672	Flow measurement in helical inducer and estimate of fluctuating blade force in cavitation surge phenomena	Furukawa A. Ishizaka K. Watanabe S.
678	Numerical study of the effect of the leading edge shape on cavitation around inducer blade sections	Coutier-Delgosha O. Reboud JL. Fortes-Patella R.
686	Behavior of vertical upward gas-liquid two-phase flow past obstacle in rectangular channel (effect of blockage ratio)	Shakouchi T. Tian DB. Ida T.

Meccanica 37(4-5) 2002

Mechanics of Materials 34(8) 2002

Mechanics of Materials 34(9) 2002

Mechanics of Materials 34(10) 2002

Medical Engineering & Physics 24(7-8) 2002

Nonlinear Dynamics 30(1) 2002

Nonlinear Dynamics 30(2) 2002

Nonlinear Dynamics 30(3) 2002

Proceedings of the Royal Society of London Series A -Mathematical Physical & Engineering Sciences 458(2026) 2002

Quarterly Journal of Mechanics & Applied Mathematics 55(Part 4) 2002

Structural & Multidisciplinary Optimization 24(2) 2002

141	Managing approximation models in multiobjective optimization	Yang BS. Yeun YS. Ruy WS.
157	A comparison of global optimization algorithms applied to a ride comfort optimization problem	Eriksson P. Arora JS.
168	Optimal design of nonsymmetric mises truss with respect to time to creep rupture	Latas W. Szuwalski K.

Structural & Multidisciplinary Optimization 24(3) 2002

175	On simultaneous shape and material layout optimization of shell structures	Ansola R. Canales J. Tarrago JA. Rasmussen J.
185	Using the response surface methodology and the d-optimality criterion in crashworthiness related problems - an analysis of the surface approximation error versus the number of function evaluations	Redhe M. Forsberg J. Jansson T. Marklund PO. Nilsson L.
195	A displacement based optimization method for geometrically nonlinear frame structures	Missoum S. Gurdal Z. Watson LT.
205	Optimal design of laminated composite beam structures	Cardoso JB. Sousa LG. Castro JA. Valido AJ.
212	Mapping method for sensitivity analysis of composite material property	Liu ST. Cheng GD. Gu Y. Zheng XG.
218	Structural shape optimization using self-adjusted convex approximation	Chung TT. Chiou CH.
225	Symmetricity of the solution of semidefinite programming	Kanno Y. Ohsaki M. Katoh N.
233	Efficient reliability-based design optimization using a hybrid space with application to finite element analysis	Kharmanda G. Mohamed A. Lemaire M.
246	Synthesis of four-bar mechanism in a hydraulic support using a global optimization algorithm	Prebil I. Krasna S. Ciglaric I.
252	Perspectives on layout and topology design	Taylor JE.
257	Extended optimality in topology design	Rozvany GIN. Querin OM. Gaspar Z. Pomezanski V.

Studies in Applied Mathematics 109(3) 2002

151	The cauchy problem for the kadomtsev-petviashili ii equation with nondecaying data along a line	Villarroel J. Ablowitz MJ.
163	A hierarchical cluster system based on horton-strahler rules for river networks	da Costa FP. Grinfeld M. Wattis JAD.
205	Dynamics of strongly nonlinear internal solitary waves in shallow water	Jo TC. Choi W.
229	The existence and stability of asymmetric spike patterns for the schnakenberg model	Ward MJ. Wei JC.

Theoretical & Applied Fracture Mechanics 38(2) 2002

109	Crack initiation behaviour of orthotropic solids as predicted by the strain energy density theory	Carloni C. Nobile L.
121	Electromechanical influence of crack velocity at bifurcation for poled ferroelectric materials	Song ZF. Sih GC.
141	Surface initiated crack growth simulation in moving lubricated contact	Ren Z. Glodez S. Fajdiga G. Ulbin M.
151	The fragmentation of cementitious composites in a jaw breaker	Momber AW.
165	Energy release rates in a constrained epoxy disc with hookean and mooney-rivlin materials	Batra RC. Ching HK.
177	Multilevel bridged crack model for high-performance concretes	Ferro G.
191	Boundary element approach to creep deformation of edge notched and cracked specimens	Providakis CP.
203	Creep behavior of crack near bi-material interface characterized by integral parameters	Tu ST.

Theoretical & Applied Fracture Mechanics 38(3) 2002

211	Anisotropic elastic constitutive relations for damaged materials by application of irreversible thermodynamics	Tang XS. Jiang CP. Zheng JL.
221	Impact response of a piezoelectric layered composite plate with a crack	Ueda S.
243	Initiation and stable growth of penny-shaped crack in aging viscoelastic transversally isotropic material	Kaminsky AA. Gavrilov GV.
255	Supersonic and intersonic cracking in rock-like material under remote stresses	Sibiriakov BP.
267	Transversely isotropic solid with elliptical inclusions or cracks	Rahman M.
281	Assessment of multiple flat elliptical cracks with interactions	Jones R. Peng D. Pitt S.
293	Dynamic meshless method applied to nonlocal crack problems	Chen YP. Lee JD. Eskandarian A.
301	Elastic-plastic and elastic anti-plane shear of two parallel cracks	Turska E. Wisniewski K.

Zeitschrift fur Angewandte Mathematik und Mechanik 82(9) 2002

Zeitschrift fur Angewandte Mathematik und Mechanik 82(10) 2002

Zeitschrift fur Angewandte Mathematik und Physik 53(5) 2002