iacm expressions

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for Computational Mechanics

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Listed in order of affiliation

U.S.A.	**U.S. Association for Computational Mechanics (USACM)**
Argentina	**Asociacion Argentina de Mecanica Computacional (AMCA)**
PR China	**The Chinese Association of Computational Mechanics**
Italy	**Gruppo Italiano di Meccanica Computazionale (GIMC)**
Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden	**The Nordic Association for Computational Mechanics (NoACM)**
Japan	**The Japan Society for Computational Engineering and Science (JSCES)**
Spain	**Sociedad Española de Métodos Numéricos en Ingeniería (SEMNI)**
Germany	**German Association of Computational Mechanics (GACM)**
France	**Computational Structural Mechanics Association (CSMA)**
U.K.	**Association for Computer Methods in Engineering (ACME)**
Greece	**The Greek Association of Computational Mechanics (GRACM)**
Austria, Croatia, Hungary, Poland, Slovenia, The Czech Republic, Slovakia	**The Central-European Association for Computational Mechanics (CEACM)**
Poland	**Polish Association for Computational Mechanics**
Bulgaria	**The Bulgarian Association of Computational Mechanics (BACM)**
Chile	**Asociacion Chilene de Mecanica Computacional (SCMA)**
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Australia	**Australian Association of Computational Mechanics**
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Turkey	**Turkish Committee on Computational Mechanics**
Brazil	**Brazillian Association for Computational Methods in Engineering (ABMEC)**
Venezuela	**Sociedad Venezolana de Métodos Numéricos en Ingeníera**
Romania	**Romanian Association for Computational Mechanics**
Mexico	**Sociedad Mexicana de Métodos Numéricos en Ingeniería**
Ireland	**Irish Society of Scientific and Engineering Computations (ISSEC)**
Korea	**Korean Association on Computational Mechanics (KACM)**
Thailand	**Thailand Society for Computational Mechanics (TSCM)**
Singapore	**Association for Computational Mechanics, Singapore (SACM)**
India	**Indian Association for Computational Mechanics**
Japan	**Japanese Association for Computational Mechanics (JACM)**
Netherlands	**Netherlands Mechanics Committee (NMC)**
Malaysia	**Malaysian Association for Computational Mechanics (MACM)**

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Fee

The annual fee for direct individual membership of IACM is 25 US dollars.
For affiliated organisations the membership fee is reduced to 10 dollars for the first fifty members, 7 dollars for the next one hundred and fifty members and 5 dollars for any member exceeding two hundred. The Bulletin and a discount on IACM supported activities (congress, seminars, etc.) are some of the benefits of the membership. For further details contact IACM Secretariat.

IACM Expressions

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IACM members are invited to send their contributions to the editors. Views expressed in the contributed articles are not necessarily those of the IACM.

contents

editorial

Much effort has been recently invested by various groups of personalities in different countries with the aim of providing a vision on the role that computational methods can play towards ensuring a sustainable progress in science and engineering. We will briefly comment on three significant outputs of these important exercises.

A report on “Computational Science: Ensuring America’s Competitiveness” was released on June 2005. The report was written by the USA President’s Information Technology Advisory Committee (PITAC report, www.nitrd.gov). The main findings and conclusions of the report are that computational science is now indispensable for the solution of complex problems in every sector, from traditional science and engineering domains to key areas as national security, public health and economic innovation. A recommendation is made to create and execute a multi-decade roadmap directing coordinated actions involving industry and academics to advance in computational science and its applications in many disciplines.

The second report was also issued in USA on February 2006 under the name “Simulation-based Engineering Science: Revolutioning Engineering Science through Simulation”. The report was written by the Blue Ribbon Panel of the National Science Foundation chaired by Prof. J. T. Oden, a former President of the IACM (see: www.ices.utexas.edu/events/SBES_Final_Report.pdf). The report concludes that we are on the verge of an enormous expansion in our ability to model and simulate an almost limitless variety of natural phenomena. The implications of this expansion are numerous and profound as it will allow us to explore natural events and engineering systems that have long defied traditional ways of study. Modelling and simulation will have applications across technologies from micro processes to the infrastructure of cities and will also enable us to design and manufacture materials and products on a more scientific basis with less trial and error and shorter design cycles. Modelling and simulation will also greatly improve our ability to predict outcome and optimize solutions before committing resources to specific designs and decisions.

Simulation methods will also expand our ability to cope with problems that have been too complex for traditional methods (ie. problems involving multiple scales of length or time, multiple physical processes and unknown level of uncertainty). Finally modelling and simulation will introduce tools and procedures that apply across all engineering disciplines (electrical, mechanical, civil, chemical, aerospace, nuclear, biomedical, materials science, etc.).

All engineering disciplines stand to benefit from advances in optimization, control, uncertainty qualification, verification and validation, design decision making and real time response, among others.

The final document is the European Commission (EC) proposal for the 7th Research Framework Programme (2007-2013) (www.cordis.lu/fp7/). The EC report describes the priority actions for EC supported research in nine specific themes: health, food, agriculture and biotechnology; information and communication technologies; innovative materials and production technologies (including the nano field); energy; environment and climate changes; transport; socio-economic sciences and security and space. It is remarkable that most of the EC planned research activities contemplate modelling and simulation as essential tools for enhanced analysis, prediction and design of products, processes and events, understood in the broad sense.

The base line of the three above mentioned documents is that computational methods are essential ingredients for the development of all branches of science and engineering. This opens a promise of new possibilities for the computational mechanics community and will surely contribute to an increasing activity in the next coming years in old and new fields.

It is a nice coincidence that these good perspectives appear at the time that IACM celebrates its silver anniversary. We take it as a birthday present and a good sign for the future.

This issue of Expressions collects some articles from distinguished IACM officers and members who have contributed with personal recollections of the 25 years of history of IACM. Time has passed on fast but not in vain and IACM has grown to be a big worldwide association with many activities held regularly all over the world.

An example of above is the 7th World Congress on Computational Mechanics of the IACM to be held in the City of Los Angeles on July 16-22, 2006. Last records show that over 2000 Abstracts have been received, which is a landmark in the history of the WCCMs. We congratulate Profs. W. K. Liu and J. S. Chen and their teams at the Northwestern University and the University of California at Los Angeles for an excellent work in organising a successful WCCM7. Yet another birthday present for the IACM!

Eugenio Oñate
President of IACM

IACM Today

By
E. Oñate
President of the IACM

> *"activities ... provide unique opportunities for spreading worldwide the on-going research in the many fields covered by the IACM"*

IACM has very much evolved since its creation in 1981. From the initial personal initiative of a group of distinguished individuals and thanks to the continuing efforts of its officers and members, IACM has grown over the years to reach nowadays 32 affiliated scientific organisations in the field of computational mechanics in 45 countries worldwide. We are now proud and happy to celebrate the 25th Anniversary of the IACM.

Table 1 shows the different scientific associations affiliated to IACM from different countries in the three geographical world regions where IACM is active.

Some IACM Associations worldwide are grouped at regional level in more global structures. This is the case, for instance, of the European Community on Computational Methods in Applied Sciences (ECCOMAS, www.eccomas.org) grouping the IACM affiliated associations in Europe, and the Asian-Pacific Association on Computational Mechanics (APACM) grouping the affiliated members in that region. Both organisations, ECCOMAS and APACM, are very active and organise regularly courses, workshops and conferences in their respective regions.

The objectives of IACM as listed in the IACM Constitution are to simulate and promote education, research and practice in computational methods, to foster the interchange of ideas among the various fields contributing to this science, and to provide forums and meetings for the dissemination of knowledge.

The main activities of the IACM are the World Congress on Computational Mechanics (WCCM). The first of these congresses took place at the University of Texas in Austin (1986) and subsequently in the Universities of Stuttgart (1990), Tokyo (1994), Buenos Aires (1998) and Vienna (2002). In the Vienna congress it was decided to change the periodicity of WCCMs to a 2 year interval. The first of the new series of WCCM took place in Beijing (China) on September 2004. WCCM7 will take place in the city of Los Angeles (USA) in July 2006. WCCM8 is scheduled for June 2008 in the city of Venice (Italy). The attendance to the WCCMs has considerable increased from the just over 500 participants in the first meeting in Austin in 1986, to some 1700 participants who are expected to attend WCCM7 in Los Angeles.

The large World Congresses in Computational Mechanics are complemented with the IACM support to the organisation of smaller size meetings such as the so called IACM Special Interest Conferences (ex. Finite Element in Fluids, Computational Plasticity, Coupled Problems, etc.), the joint IACM/IASS conferences on Computation of Shell and Spatial Structures, (Crete, Greece, June 2000 and Salzburg (Austria) June 2005) and the joint IACM/IUTAM workshops. Full details of on-going and past events of this kind can be found in the IACM web page (www.iacm.info)

The activity of the IACM is also reflected in the different events organised by each of the 32 affiliated organisations. Most of these associations hold conferences and workshops which take place at national or regional level at periodic intervals. For instance, the First South American Congress on Computational Mechanics was held in Paraná (Argentina) on November 2002 and the second one is foreseen in Foz de Iguazu (Brazil) on 2008. Both congresses promoted by the very active associations of Argentina and Brazil put the foundational stone for a new regional IACM association in South America.

The national and regional activities of the IACM provide unique opportunities for spreading worldwide the on-going research in the many fields covered by the IACM, as well as being a forum for interchange of ideas and personal knowledge between scientists and engineers from different countries.

Of particular relevance are the activities promoted by the regional associations representing IACM's interests in Europe (ECCOMAS) and in the Asian Pacific region (APAMC). For instance APAMC organises regularly a regional congress on Computational Mechanics. The last of these congresses was held jointly with WCCM6 in the city of Beijing on September 2005.

ECCOMAS, on the other hand, is particularly active in the organisation of a large congress on Computational Methods in Applied Sciences and Engineering held at every four years interval, as well as mid-size conferences on Computational Fluid Dynamics and Solids and Structural Mechanics. The next ECCOMAS congress will be held on June 2008 in conjunction with WCCM8 in the beautiful city of Venice in Italy.

In addition, ECCOMAS has succeeded in organising since 2003 smaller size events called Thematic Conferences. These conferences focus on specialised and emerging topics in the field of Computational Engineering and Applied Sciences. The ECCOMAS Thematic Conferences take place at every two years interval and their number has increased from 7 events in 2003, 15 in 2005 and 21 Thematic Conferences planned for 2007. See www.eccomas.org for details of the ECCOMAS activities.

IACM recognizes the outstanding work of individuals through a number of Awards such as the Gauss-Newton Medal (the highest award given by IACM), the IACM Award for Computational Mechanics given for contributions in traditional research areas such as computational structural mechanics and fluid dynamics, the IACM Award honouring special individual contributions in research, leadership and/or industrial applications and the Fellow Award recognising individuals with a distinguished record of research in the areas of computational mechanics. A list of past IACM awardees can be found in the IACM web page.

We should also note the role of IACM Expressions magazine, helping to disseminate IACM activities in an amenable way. Happy birthday also to IACM Expressions which celebrates its 10th anniversary in 2006

Future challenges

The challenges of the IACM for the next coming years are to harmonize and find a balance between the increasing number of activities organised worldwide by national and regional organisations, with the general scope of the World Congress on Computational Mechanics held every two years in rotation around the three geographic areas of the world. Indeed, the positive experiences in merging the WCCM with large regional congresses seems the trend to be followed in the future.

The increasing number of IACM affiliated associations indicates also the need to give these members a more visible role in the organisation and management of the IACM activities worldwide. The clustering of national associations into wider regional bodies will favour the implementation of new successful activities in different countries at each world region. An example of this are the ECCOMAS Thematic Conferences in Europe.

Last but not least, a challenge of the IACM is to evolve from being a "confederation" of scientific organizations to an association where individual persons, either students, scientists and engineers, are clearly identified. Our goal is that through the intellectual benefits and opportunities generated by the IACM activities, these persons recognise the value of being a member of the IACM. ●

Associations	Country
AMERICAS	
U.S. Association for Computational Mechanics (USACM)	USA
Asociación Argentina de Mecánica Computacional (AMCA)	ARGENTINA
Sociedad Chilena de Mecánica Computacional (SCMC)	CHILE
Brazilian Association for Computational Mechanics (ABMEC)	BRAZIL
Sociedad Venezolana de Métodos Numéricos en Ingeniería	VENEZUELA
Sociedad Mexicana de Métodos Numéricos en Ingeniería (SMMNI)	MEXICO
EUROPE-AFRICA-MIDDLE EAST	
Associazione Italiana di Meccanica Teorica e Applicata (AIMETA / GMC)	ITALY
The Nordic Association for Computational Mechanics (NoACM)	NORDIC EUROPEAN COUNTRIES (Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden)
Sociedad Española de Métodos Numéricos en Ingeniería (SEMNI)	SPAIN
German Association of Computational Mechanics (GACM)	GERMANY
Computational Structural Mechanics Association (CSMA)	FRANCE
Association for Computer Methods in Engineering (ACME)	UNITED KINGDOM
The Greek Association of Computational Mechanics (GRACM)	GREECE
The Central-European Association for Computational Mechanics (CEACM)	CENTRAL EUROPEAN COUNTRIES (Austria, Croatia, Hungary, Poland, Slovenia, The Czech Republic)
Polish Association for Computational Mechanics (PACM)	POLAND
The Bulgarian Association of Computational Mechanics (BACM)	BULGARIA
The Israel Association of Computational Methods in Mechanics (IACMM)	ISRAEL
Associação Portuguesa de Mecânica Teórica, Aplicada e Computacional (APMTAC)	PORTUGAL
Romanian Association for Computational Mechanics	ROMANIA
Irish Society for Scientific &Engineering Computation (ISSEC)	IRELAND
Netherlands Mechanics Committee (NMC)	NETHERLANDS
South African Association for Theoretical and Applied Mechanics (SAAM)	SOUTH AFRICA
Turkish Committee on Computational Mechanics - Istanbul Technical University	TURKEY
ASIA-PACIFIC	
The Chinese Association of Computational Mechanics	P R CHINA
Japan Society of Computational Science and Engineering (JSCSE)	JAPAN
Australian Association for Computational Mechanics (AACM)	AUSTRALIA
Korean Association on Computational Mechanics (KACM)	SOUTH KOREA
Thailand Society of Computational Mechanics (TSCM)	THAILAND
Singapore Association for Computational Mechanics (SACM)	SINGAPORE
Indian Associacion of Computational Mechanics (IndACM)	INDIA
Japan Association for Computational Mechanics (JACM)	JAPAN
Malaysian Association for Computational Mechanics (MACM)	MALAYSIA
Indonesian Association for Computational Mechanics (IndoACM)	INDONESIA

Table 1.
IACM affiliated organisations worldwide. Associations are listed in each box in order of affiliation.

The Beginnings of IACM

"What were the expectations of IACM and have we lived up to them?"

by

O.C. Zienkiewicz

President of IACM
1986 - 1990

Figure 1: (right)
Olek before Finite Elements
at the beginning of his academic career, in1952

By the mid '70s of the last century the Finite Element Method became a widely recognised tool. Its usage was widespread, not only in structural engineering where it started, but in fluid mechanics, electro magnetics, etc. Further, a number of mathematicians entered the fray and FEM was also declared to be precise and acceptable (which, of course, we engineers considered to be already well proven).

Many meetings and conferences were taking place each year, often in overlapping areas, and the meetings in general were not co-ordinated. It occurred to some of us that some form of organisation would be desirable and that every few years we should run a big congress associated with an international organisation. Richard Gallagher, Tinsley Oden and myself devoted much time in discussion of this subject throughout the '70s and by the beginning of the '80s felt well placed to launch such an organisation. A meeting was held in Atlanta in which many representatives of various parts of the world were present and it was here we decided to approach the senior people from several countries and suggest our ideas. These were accepted with enthusiasm and thus the meeting on hybrid and mixed methods held in Atlanta Georgia in the spring of 1981 can be considered as the time of the launching of IACM.

Obviously much detail had to be worked out and decisions taken as to where to launch the first meeting. We decided then that the pattern already used by an organisation which started at the beginning of the 20th century, the International Association of Theoretical and Applied Mechanics (IUTAM), could well provide a model, at least of the general format. We did not envisage being state-sponsored in the manner of that organisation and planned to use a somewhat different approach here. However, their pattern of a 4-year period between international congresses seemed perfect for our needs and we adopted this with alacrity. It was necessary, however, to decide where the first congress would be held and also where future congresses would be held taking into account various world-wide locations. Here, one of the fundamental principles which we thought of incorporating in the Association, was to divide the world into three regions. Three obvious regions immediately materialised. The first would be the Americas North and South. This would be followed by a second region made up of Europe in the north and Africa in the south and, lastly, a third Australasian region to include India, Australia, Japan, China and all the eastern countries within this area.

It was soon decided between us that the first congress should be held in Austin Texas, the home of Tinsley Oden, and after four years to be followed in some location in Europe. We then chose Stuttgart, the home of John Argyrus.

The title of the association was to be The International Association of Computational Mechanics and so after 25 years we still remain with the same title. Some of us felt that the addition of "and Engineering" to the title of the organisation, thus making its abbreviation IACME, would be desirable as not all the applications of numerical methods were in the field of mechanics. It was difficult, for instance, to apply the earlier title to electro magnetics or the complete field of fluid mechanics. I think this name change still remains an option which some of us may wish to adopt in the future.

The constitution of IACM was duly drafted and I shall not refer to its details. However, one thing became clear. It was that the finite element methodology, although obviously most popular, would not necessarily be the only methodology discussed in the conferences. Finite differences, boundary integrals and other methods could offer certain advantages for limited problems and it was desired to continue with their presentations at the congresses.

It is interesting to see, however, that at the first congress, the staunch proponent and practitioner of the Finite Difference Method, Professor Anthony Jameson, gave his first Finite Element paper. This showed that an irregular division of space into tetrahedra could result in solution of aerodynamic problems. He gave as an example a calculation of flow around the 747 Boeing. This certainly proved a great encouragement to the finite element fraternity who up to that time had seen finite differences still being the major computational tool being used in fluid mechanics and aeronautics.

What were the expectations of IACM and have we lived up to them?

Well, it was felt by many that now we would have a central forum for discussion of research which would stretch right across the world. It would mean that many small and uncoordinated meetings could now be eliminated. Of course, aspirations like that are never quite fulfilled. We do have now the series of large meetings. In addition, each of the regions holds its own congresses, some of them being very big meetings like those held by the U.S. Computational Mechanics Society and ECCOMAS in Europe, etc. In addition we introduced a set of smaller meetings concentrating on special interest topics. These meetings are still associated with IACM and we believe that in future their number will indeed expand.

Such specialised conferences previously were handled by individual universities and a certain continuity has thus been established. I of course am glad to see that the Finite Elements in Fluids Conference, first held in Swansea in 1974, is continuing having held its last meeting under the aegis of IACM in 2004 again in Swansea. Another conference, dealing with the interesting problem of mesh generation and error estimation, was launched in Gothenburg two years ago and this year it continued with its second meeting of the series (in Barcelona). Many such specialised meetings will continue and we note with great pleasure that IACM here again provides a leading role.

Meanwhile in Europe a separate organisation was set up, that of ECCOMAS which when started had little connection with IACM. Today ECCOMAS is almost a part of the larger organisation and collaborates closely with it by organising the European regional meetings. The next congress of ECCOMAS will indeed provide the venue for the International World Congress to be held in Venice in three years' time.

It may be of interest to note that the four-year cycle of congresses did not continue permanently. In *figure 1* we show the number and year of each of the four-yearly congresses up to the fifth in 2002. At that time a decision was taken to always organise the World Congresses simultaneously with one of the regional congresses. The first of these joint meetings was held in 2004 in Beijing China and this will be followed by one in Los Angeles in 2006 and in Venice in 2008. This more frequent arrangement of meetings at two-year intervals does not seem to detract from their attendance and indeed the Chinese congress, as far as I understand, gathered some 2,000 participants.

The reader will note that IACM has become a popular and widely spread organisation. At the early meetings of IACM it was decided that we should have a general council listing possibly 80 – 100 well-known researchers, as well as a much smaller executive council which would help the President and Secretary with day-to-day decisions which would have to be taken.

It seems important to me in retrospect that one location should be chosen to hold a permanent secretariat, even though the actual Secretary's appointment and his nationality may change from time to time. It has been very effective to have much of the administrative work concentrated in Barcelona under the guidance of Professor Oñate and we hope that this placing of the secretariat may well continue in the future. It was also from Barcelona that we have seen the start of the very effective quarterly journal 'EXPRESSIONS' which provides a friendly forum for members of IACM in the three regions.

The general management of the Association and choice of its direction is governed by a small executive council of approximately fifteen members who appoint a President, two Vice Presidents and a Secretary. These appointments are made at the four-year intervals, although here we have not yet written any specific rules. It was a very great honour for me that at the first congress in Austin I was elected as the President of the Association with Dick Gallagher and Tinsley Oden being Vice Presidents. Both of these have, of course, become presidents in following years. The post of Secretary in the first period was given to Professor Alf Samuelsson (who unfortunately passed away last year). His location at Gothenburg proved a good one as the General Secretary of IUTAM was also located there and Professor Samuelsson could from time to time discuss general aspects of organisation with him. We feel that some such discussions between the two organisations could well be continued in the future. Now that the first 25 years are over we can give further attention to such organisational matters. Looking back at that period, I am happy with the achievements that have been made and the progress of IACM in various countries. In Europe and the two other regions most of the nations belonging to the Association have their own national meetings and it is rather important that these should be the foundation of the whole Society. I am sure much more has to be done to achieve this aim and thus make IACM available to a very wide audience. •

Figure 1:

IACM Congresses

Four year cycle

1. **1986** **Austin Texas** USA
2. **1990** **Stuttgart** Germany
3. **1994** **Tokyo** Japan
4. **1998** **Buenos Aires** Argentina
5. **2002** **Vienna** Austria

Two year cycle

(combined with Regional Congresses)

6. **2004** **Beijing** China
7. **2006** **Los Angeles** USA
8. **2008** **Venice** Italy

Remin

International Mecha and my

> *"IACM ... provided me with opportunities to continue my friendship with my earlier contacts as well as to make new contacts ... ?"*

In my opinion, three scholars – Professor Clough, Professor Zienkiewicz and Late Professor Argyris - have made significant contributions to computational mechanics during the modern times through the development and promotion of finite element method.

If one follows Hinduism, they can be considered as 'Trimurti' – Brahma, Vishnu and Shiva. Or if one follows Christianity, they can be considered as 'Holy Trinity' – Father, Son and Holy Spirit.

So, let me start my reminiscences from my contacts with the three doyens of FEM.

During my Master's studies in US (1961-63), I was motivated to do my later research in FEM due to the publication of Clough's paper on 'The finite element in plane stress analysis' published in 1960. In fact, my Master's project was to write a program on that. Unfortunately, I did not meet Professor Clough till 1999 during the ECCM in Munich organized by Professor Wunderlich who had the insight and luck to bring the three doyens together-what a wonderful sight it was!

After I left US in 1964, I was lured to Swansea by Professor Zienkiewicz to do my Doctoral research in FEM. The period 1965-69 when I was there, can be considered the 'golden period' and Swansea indeed became the 'seat of learning' for FEM.

iscing on my contacts with the Computational nics Community Role in IACM

by
Somasundaram Valliappan
University of New South Wales
Sydney, Australia

Prof.Zienkiewicz with Prof.Cheung and Prof.Valliappan
(1st and 2nd doctoral students of OCZ in computational mechanics) during the 1st Asian Pacific Conference on Computational Mechanics organized by Prof.Cheung in Hong Kong.

The 2nd Asian Pacific Conference was organized by Prof.Valliappan in Sydney. Prof.Zienkiewicz was the 1st President, Prof.Cheung the 2nd Vice President and Prof.Valliappan the 3rd Vice President of IACM

In the course of my Doctoral studies, I wanted to meet Professor Argyris to clarify some points related to his manuscript ‘Energy Theorems and Structural Analysis’ published in 1960. At that time Professor Argyris was holding two Chairs-one in Imperial College, London and another in the University of Stuttgart-. So it used to be difficult to get an appointment with him. After a few attempts, I was successful to meet him in 1966 and it was a memorable meeting!

While I was in Swansea, I had a lot of opportunities to meet a number of researchers in FEM, notably, Late Professor Irons (isoparametric elements), Late Professor Fraeijs de Veubeke (equilibrium elements) and Professor Pian (hybrid elements).

Even after leaving Swansea in 1969, I found it to be a good meeting place for making contacts. During the first Conference on Flow Problems in 1974, I had the opportunity to make acquaintances of Professors Oden, Kawai and Yamada. I was also fortunate to make the friendship of Late Professor Gallagher through Professor Zienkiewicz. Dick Gallagher came to Sydney as a Visiting Professor in UNSW at my invitation in 1973. On my behalf he also presented my first paper in the field of biomechanics on ‘Stress analysis of human femur’ in the conference organized by Yamada in Tokyo.

Later, during the conference NUMETA held in Swansea in 1985, I had the opportunity to make contacts with Professors Mang, Wunderlich, Taylor, Ohayon and Samuelsson. My contact and friendship with the first four still continue.

Regarding my role in IACM, I have been a Founding Member of the General Council since its inception in 1981, then Corresponding Member, Member of the Executive Council and now Vice President (Asia-Australia).

IACM and especially World Congresses (WCCM) have provided me with opportunities to continue my friendship with my earlier contacts as well as to make new contacts with numerous researchers in computational mechanics. World Congresses have been a wonderful forum not only for me to engage in technical activities but also for my wife to make social contacts and close friendship with the wives of my contacts mentioned here.

As to my promotional activities in IACM, I am proud that I have been instrumental in the establishment of national associations in Asia-Pacific Region – Singapore, Malaysia, Thailand, Hong kong, Korea and Indonesia especially after I became the Vice President.

Finally, my best wishes to IACM for its Silver Jubilee and for continuing its excellent activities through WCCM which started 20 years ago in 1986 and through ‘IACM Expressions’ which started as ‘IACM Bulletin’ in 1985. ●

From TICOM to ICES, and the first quarter century of IACM

by
J. Tinsley Oden
The University of Texas at Austin

"I have seen ... [CM] grow
from its early beginnings
to a discipline with broad impact
on all areas of science and engineering
... the scope of IACM is without boundary."

The twenty-fifth anniversary of IACM provides an opportunity to make some personal reflections on the discipline of computational mechanics (CM), its broader, more recent manifestations as the discipline of computational engineering sciences (CES), and on how I've dedicated much of my time and energy to study, advance, and promote these subjects over the last quarter century.

The subject CM itself began to gel in the 1960's and 1970's with the realization that the rapidly developing technologies of scientific computing could give life to the most complex theories of mechanics and that computer simulations based on computational models could impact virtually every aspect of human life.

The term "computational fluid mechanics" (CFD) became part of technical language in the 1970's. This was the period when some of us began to realize the great importance of the interactions of applied mathematics, numerical analysis, and theoretical mechanics as the core of a new discipline that would bring computational tools to the forefront of engineering and science. I, together with a small group of colleagues, decided to call the discipline computational mechanics to emphasize that its was much broader than CFD and encompassed solid mechanics and materials science as well. We organized an interdisciplinary group to focus academic study and research on the new discipline, and we called that group TICOM: the Texas Institute for Computational Mechanics. As some of the older members of IACM will recall, we organized several international meetings on the subject of computational mechanics in the 1970's. By the 1980's, it was clear that CM was a worldwide activity and that some coherent structure was needed to focus on the subject as a new and incredibly valuable discipline, a structure that would provide a forum for collaboration and exchange of new developments in CM on a worldwide playing field.

Thus, IACM was born.

I had the honor of being President of that organization from 1990-1994. Only a few years after retiring from that office, a significant expansion of TICOM occurred, acquiring the name of TICAM (Texas Institute for Computational and Applied mathematics) to recognize a broader scope and a focus on a deeper mathematical approaches to computational methods. From the beginning, TICAM was only meant to be the first phase of a broader vision designed to eventually cover all the fields of computational engineering and science.

The second phase of this initiation occurred in 2003 with the creation of the Institute for Computational and Engineering Sciences (ICES). I want to take an opportunity to describe ICES and what is happening there. In January 2003, the decision was made by The University of Texas to begin to develop a broad extension of TICAM to cover all areas of computational science and engineering: biology, biomedicine, chemistry, biochemistry, physics, geology, and all areas of engineering, computational and applied mathematics and portions of computer science. Significant resources

were supplied by the University and by outside philanthropic foundations and an initiative began which had as its goal the creation of the top center for research and academic study in CES in the world. ICES was created as an interdisciplinary organized research unit with a mission: to provide the infrastructure and intellectual leadership for developing outstanding interdisciplinary programs in research and graduate study in the computational sciences and engineering and in information technology.

The Institute is located at the Applied Computational Engineering Sciences Building, a building that was completed in 2000 for the specific purpose of providing a home for ICES and complementary units of computer sciences and electrical and computer engineering.

The Institute also manages the Ph.D. program in Computational and Applied Mathematics (CAM). It draws faculty from four colleges and schools, and 17 academic departments, including all the departments within the College of Engineering and most of those within the College of Natural Sciences, with units from the Schools of Geological Sciences and Business. About 80 faculty participate in various ICES activities. Students in the CAM Program do not follow traditional lines of study. Their focus is on interdisciplinary work, taking core courses in applicable mathematics, numerical analysis and scientific computing, and an application area called mathematical modeling and applications. A large endowment is in place that supplies resources for Graduate Fellowships for qualified students. The Institute's endowments of over $70 million also cover an active Postdoctoral Fellowship Program that brings in top postdoctoral fellows into the Institute each year for a period of 1-2 years.

The jewel of the Institute is its Visiting Faculty Fellowship Program. Funds from the endowed program support an active program in which senior scholars visit ICES to collaborate on research projects with ICES faculty for periods of two weeks or more, some spending months or semesters at the Institute. Office space and clerical and technical support are provided to visitors, together with access to the Institute's library, seminar series, and report series. Each year, around 50 visitors participate in this program. Roughly a third come from the United States and the rest from other countries.

The strongest and most important asset of the Institute is its outstanding faculty. Sixteen chaired, or endowed professors, sit on the ICES Advisory Board. They include: Ivo Babuska, Mary Wheeler, Bjorn Engquist, Thomas J.R. Hughes, Omar Ghattas, James Chelikowsky, Luis Caffarelli, John Boisseau, Leszek Demkowicz, James C. Browne, Graham Carey, Greg Rodin, William Beckner, Chandrajit Bajaj, and Peter Rossky.

Figure 1:
The ACES Building, home of ICES.

Figure 2:
ICES Advisory Board

A number of other distinguished scientists and engineers who work in computational and applied mathematics and computational mechanics belong to the Institute.

Throughout the Institute, several multi-processor clusters are in operation, all of which are connected via a high-bandwidth network to the University's supercomputing center, where connections to the national Teragrid exist, so that large-scale grid computing can be accommodated nationwide. Research activities at the Institute now span a remarkable gamut of subjects: cardiovascular surgery, laser treatment of cancer, earthquake modeling, quantum mechanics and electronic properties of materials, nanodevices and semiconductors, electromagnetics, acoustics and wave propagation, fluid mechanics, turbulence and combustion, computational finance, distributed and grid computing, and computational biology. A litmus test for the research work done at the Institute is its interdisciplinary character. The Institute provides the environment for easy cross-disciplinary interactions, collaborations and research. Students in the CAM Program are immersed in this interdisciplinary environment.

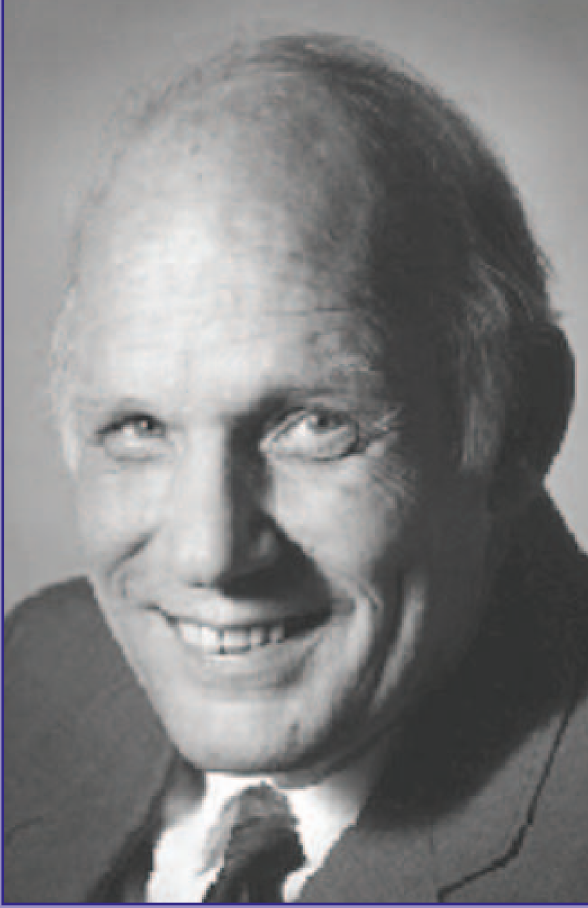
So, over the past twenty-five years, I have seen the subject of computational mechanics grow from its early beginnings to a discipline with broad impact on all areas of science and engineering. This increase in breadth is happening on a worldwide scale. IACM will continue to champion CM and will also embrace these broader computational fields. Computational Mechanics, after all, is the discipline concerned with the application of computational methods and devices to problems in mechanics, and mechanics is the study of the behavior of bodies under the action of forces. These bodies and focus can be in any biological, chemical or physical system. So the scope of IACM is without boundary.

I feel honored to have been a part of this association and a member of the community of scientists and engineers who have attempted to contribute to the advancement of CM. ●

J. Tinsley Oden
ICES, 2006

Personal Recollections of
Robert L. Taylor
and his Contributions to
Computational Mechanics

by
Thomas J.R. Hughes
The University of Texas at Austin



Robert L. Taylor

"... a great researcher,
teacher, mentor, collaborator and friend."

Everyone active in the field of Computational Mechanics knows the name of Robert L. Taylor, but not everyone knows what he looks like. If you go to his website you will find the accompanying picture. Remarkably, this picture really looks like Bob!

I encountered Bob through his writings before I ever met him. The paper that drew my attention to his work concerned finite element formulations of orthotropic incompressible elasticity, authored by Taylor, Pister and Hermann [1]. Soon after I arrived at Berkeley in August 1969 to pursue graduate studies, I met Bob in the flesh. I came to Berkeley to work with Karl Pister, whose research group was known as the "Pister Research Machine," or "PRM."

Bob had been Karl's Ph.D. student and it quickly became very clear that Bob was the "Chief Operating Officer" of the PRM. Bob visited with all the students in the PRM each day, reviewing their progress and guiding their work. My first recollections of him were that he was usually laughing and joking - he seemed like a happy man (and he still does!). I had hardly gotten to know him when he left shortly thereafter for his first sabbatical in Swansea, Wales, where he began his friendship and collaboration with Olek Zienkiewicz which lasts to this day. While in Swansea, Bob wrote "FEAP" but that FEAP is not the FEAP that is used throughout the world today. (More about this in a moment.) During this time Bob, Olek and Jim Too collaborated on reduced integration procedures for plates and shells and wrote a paper that became a classic [2].

Bob returned to Berkeley in 1970 after his sabbatical. I was on fellowship and off studying mostly mechanics and mathematics at the time, and had almost no interaction with Bob until the summer of 1973. Bob and Jerry Sackman were awarded a research contract to develop a numerical formulation for contact and impact problems. Jerry asked me if I could come up with some formulative ideas.

I wrote up some notes and gave them to Bob and soon after, I joined the project. Bob and I began an intense period of collaboration on all things FEM that lasted until the summer of 1976 when Bob returned to Swansea for a second sabbatical and I left to teach at the California Institute of Technology.

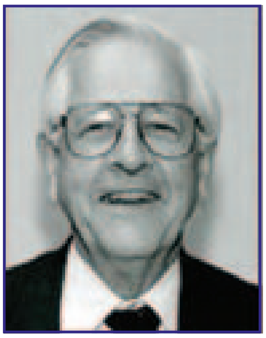


Figure 1:
Karl Pister

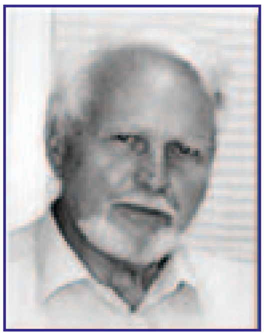
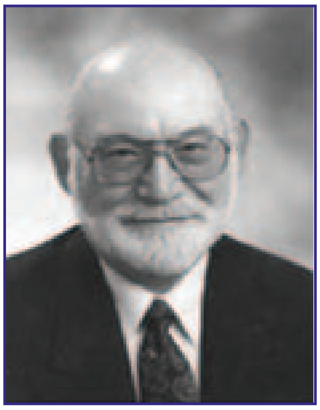


Figure 2:
Olek Zienkiewicz

Figure 3:
Jerry Sackman



I completed my Ph.D. thesis in 1974 and because I was working so closely with Bob at the time many people assume he was my Ph.D. advisor. This was not the case. My Ph.D. advisor was Jacob Lubliner, and the other members of my reading committee were Alex Chorin and Stan Burger. The year I filed Stan left for a sabbatical so Bob took his place, and was a great help despite the fact that the topics, arterial pulse propagation and finite differences, were unfamiliar to him.

During the period 1973-1976 Bob and I wrote several papers that became quite well known. Our Initial work on contact and impact was published in 1976 [3]. Bob's former students, Worsak Kanoknukulchai and Alain Curnier, both well-known professors, were also key players in this activity. We also developed penalty methods and reduced and selective integration procedures for fluids [4]; reduced and selective integration elements for plates [5]; and the HHT method for structural dynamics [6]. There is an amusing story about this paper. Interest in HHT increased significantly in the mid-1990's but, according to the Citation Index, there were no citations after 1988. Something was wrong as it was indeed frequently cited, but what? A while ago I noticed a reference to this paper in which the senior author's name was written "H.M. Hilbert." The senior author was H.M. Hilber (no "t"). Hans Hilber was a Ph.D. student of Bob's who pursued a professional career at RIB in Germany. Hilber is not that common a name scientifically but Hilbert certainly is; David Hilbert was one of the most famous mathematicians who ever lived (*figure 4*).

Figure 5:
"Louis, I think this is the beginning of a beautiful friendship," - Humphry Bogart to Claude Rains in Casablanca, 1941

Figure 4:
Not *Hans Hilber*

I checked a little further and found this mistake was not uncommon. I searched and found the missing attributions under "H.M. Hibert" in Citation Index, and I also found a mistake in the journal name, but now everything has been fixed. It turns out that [6] is the most cited paper in the history of the journal *Earthquake Engineering and Structural Dynamics.*

Bob and I collaborated on other innovations during the period 1973-1976, in particular, the first consistently linearized inelastic constitutive algorithm [7] and the ***F*** approach in finite deformation inelastic analysis [8]. The ***F*** approach actually preceded the popular ***B*** method, but [8] was never published in the open literature. In those days it did not seem important to publish *everything* in journals.

In 1975 Bob wrote the first version of "MINIFEM" (the real FEAP) on a plane ride we took together to attend an ASME meeting in Houston and visit with J.Tinsley Oden and colleagues in Austin. Here is how MINIFEM became FEAP: During Bob's second sabbatical in Swansea he collaborated with Olek on the third edition of The Finite Element Method. They decided to include MINIFEM, which was a small, nicely-structured nonlinear code, and an ideal vehicle for teaching finite element programming. But MINIFEM had not been developed at Swansea whereas FEAP had. So MINIFEM was renamed FEAP and the original FEAP was retired. The original FEAP had become very large and complicated by the mid 1970's. When Worsak Kanoknukulchai first became Bob's student, he stayed awake all night and flow-charted it on enormous pieces of paper spread out on the floor. It was an amazing accomplishment. I do not know where the term "spaghetti code" originated, but for me it was in Worsak's flow chart.

Bob and Olek have collaborated on all subsequent editions of *The Finite Element Method*. The 6th edition has just appeared in a three-volume set [9-11] and it is indeed a remarkable accomplishment.

Bob has written many highly cited papers over the years. I will mention a few here. His paper on incompatible modes [12] was a fundamental contribution to element technology that anticipated many subsequent developments in assumed strain methods. This was the paper that elicited the comment in Gil Strang's classic book, *An Analysis of the Finite Element Method*, "Two wrongs make a right, at least in California." Bob also

Figure 6:
Some friends of Bob Taylor a the Drucker Medal symposium in November 2005
From left to right: J.S. Chen, Peter Pinsky, Worsak Kanoknukulchai, Kasper Williams, Tom Hughes, Krishna Garikipati and Loc Vu-Quoc

had a most fruitful collaboration with the late Juan Carlos Simo. Together they produced many significant contributions to the literature. A sample of the most prominent includes pioneering works on the treatment of the incompressibility constraint in finite deformations [13], the "patch test" [14], and constitutive algorithms [15-17]. I think it is fair to say that [15] is perhaps the most influential paper ever written on computational plasticity.

It goes without saying that Bob is one of the most cited engineers in the world. He was among ISI Thompson's original 100 "Most Cited Engineers." Bob has also continued the development and dissemination of FEAP, which has become the primary research platform in Computational Mechanics.

Over the years Bob has mentored many graduate students and post-docs who have also become very prominent in the field. He has received many honors, including the Berkeley Citation, membership in the U.S. National Academy of Engineering, the Von Neumann Medal of USACM, the Gauss-Newton Medal of IACM, and honorary doctorates from Swansea and Hannover. He holds the titles T.Y. and Margaret Lin Professor of Engineering Emeritus and Professor in the Graduate School at the University of California, Berkeley, where he has spent his entire academic career. In November 2005, Bob was awarded the Drucker Medal from ASME and a symposium was held in his honor.

What does it take to attain greatness in the field of Computational Mechanics? Here is my personal list: You should be a great researcher, a great teacher, a great mentor, a great collaborator and a great friend. Bob Taylor is all of those things! ●

Figure 7:
Wing Kam Liu and Bob at the presentation of the Druker Medal

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25 Years of IACM
Personal Recollections

> *"The great success of IACM in the promotion of computational mechanics during the last 25 years is the consequence of the collective effort of the affiliated organizations and last, but not least, of their members."*

Shortly after my appointment to the Chair of Strength of Materials at Vienna University of Technology, in 1983, Prof. Richard H. Gallagher, invited me to become a member of the Council of the International Association for Computational Mechanics (IACM). He had known me already since 1975 when I joined the Department of Civil Engineering of Cornell University, of which he then was Chairman, as a Max-Kade Research Fellow. Up to this day, I consider this invitation by my American mentor as a milestone in my professional career.

Figure 1:
Opening Ceremony of the WCCM V (from right to left), Thomas J.R. Hughes - then President of IACM, Michal Kleiber - at that time Minister for Science and Research of the Republic of Poland, Herbert A. Mang and Franz G. Rammerstorfer, Congress Chairmen, and Josef Eberhardsteiner, Secretary General of WCCM V

My pride in this membership seems to have passed unnoticed by the organizers of the First World Congress on Computational Mechanics (WCCM I), in Austin, Texas, in 1986. My lecture took place in a small room in the basement of a motel. Whether it was the remoteness of the lecture room or the topic of my lecture that attracted only 6 attendants will remain unknown for ever. Anyway, Dick Gallagher was one of the six, which was a consolation to me.

In 1991, Dr. Miloslav Okrouhlik from the Institute of Thermomechanics of the then Czechoslovakian Academy of Sciences, upon recommendation by Prof. Ivo Babuπka, suggested the foundation of the Central

by

Herbert A. Mang

Vice President of IACM

President of ECCOMAS

European Association for Computational Mechanics (CEACM) as a regional association affiliated to IACM. When naming Austria, Croatia, Czechoslovakia (before the political split into the Czech Republic and Slovakia), Hungary, Poland, and Slovenia as the countries represented in CEACM, Dr. Okrouhlik jokingly referred to CEACM as an association of the former Austro-Hungarian monarchy.

From 1992-1995, I had the honor to serve as President of CEACM. This regional association was instrumental in putting Central Europe on the map of scientific activities in computational mechanics.

It was at WCCM III, in Chiba, Japan, in 1994, that Prof. J. Tinsley Oden informed me about my election to the Executive Council of IACM, which came to me as a big surprise. I have always regarded this election as a great privilege and have made efforts to attend the meetings of the EC and to contribute to the solution of problems which IACM has had to face.

At WCCM IV, in Buenos Aires, in 1998, Prof. Franz G. Rammerstorfer and I submitted a bid for the organization of WCCM V in Vienna. The success of our bid was the start of a period of work of increasing intensity. In passing, I would like to mention my election to Vice President of IACM, which I consider as a great honor.

In a press conference immediately before the Opening Ceremony of the WCCM V on July 8, 2002, the impact of computational mechanics on technological progress was emphasized by the panellists, among them (see the photo from right to left), Thomas J.R. Hughes, then President of IACM, Michal Kleiber, at that time Minister for Science and Research of the Republic of Poland, Herbert A. Mang and Franz G. Rammerstorfer, Congress Chairmen, and Josef Eberhardsteiner, Secretary General of WCCM V. Computational mechanics was presented to the press as a far-reaching field, ranging from basic science over applied research to applications in a variety of engineering disciplines. Its prominent role among the fields in the lead of technological progress was portrayed. The approximately 1480 registered participants and 120 accompanying persons were coming from 57 different countries.

WCCM V was the largest congress in the relatively short history of computational mechanics. It reflected the impression about computational mechanics as a dynamic field living up to its claim of a discipline on the forefront of technological progress.

WCCM VI, in Beijing, in 2004, was a great success and WCCM VII, in Century City, California, in this year, certainly will be one.

My personal recollections are spanning a period of 23 years from the third year after the foundation of IACM up to now. It would be nice if I could celebrate my personal jubilee of 25 years of service to IACM, in 2008. In this year, for the first time, a congress jointly organized by IACM and ECCOMAS (European Community on Computational Methods in Applied Sciences) will take place. The site of WCCM VIII and ECCOMAS 2008 will be Venice.

Now, however, it is time to congratulate IACM on the occasion of its 25th birthday. The great success of IACM in the promotion of computational mechanics during the last 25 years is the consequence of the collective effort of the affiliated organizations and last, but not least, of their members.

Their dedication to the cause of IACM is the condition for future success. •

> *"It would be nice*
> *if I could celebrate*
> *my personal jubilee*
> *of 25 years of service to*
> *IACM, in 2008 ...*
> *in Venice."*

Summary of

The Top 10 Computational Methods of the 20th Century

by
Dan Givoli
Israel Institute of Technology

First published in IACM Expressions September 2001

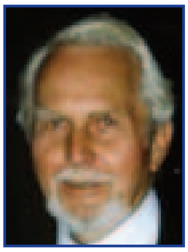
In the January/February 2000 issue of the journal Computing in Science & Engineering, a joint publication of the American Institute of Physics and the IEEE Society, the guest editors J. Dongarra and F. Sullivan put together a list they entitled "Top Ten Algorithms of the Century." Their goal was "to assemble the 10 algorithms with the greatest influence on the development and practice of science and engineering in the 20th century". In the May 2000 issue of SIAM News, B.A. Cipra briefly described these 10 algorithms. In September 2001 the complete list was published here in IACM Expressions, and for our newer members, here is a brief list of these 10:

1. The Finite Element Method (FEM)

How could FEM be forgotten in the original list? No need to tell the readers of IACM Expressions how central in CM FEM is. It is often claimed that FEM is the single most important invention in computational engineering. FEM can be described as a general method for the approximate solution of partial differential equations based on a variational (or a weak) formulation. The method was originally devised by the famous applied mathematician R. Courant in 1943, but was totally ignored (mainly because of lack of computers back then) until it was reinvented by engineers in 1956. One of the pioneers was R. W Clough, who also coined the term 'finite elements'. Other recognised early developers include O.C. Zienkiewicz and J. Argyris. Closely related to FEM is the Boundary Element Method which was developed much later, and combined known integral equation techniques and FEM ideas. The first work using BEM in its modern form can be traced back to a seminal paper by T.A. Cruse and F.J. Rizzo in 1968 .


R. Courant


J. Argyris


O.C. Zienkiewicz

2. Interactive Linear Algebraic Solvers

Almost every single numerical method in CM involves the solution of a linear algebraic system, $Ax = b$. It is well known that direct solution methods like Gaussian Elimination are effective only for small and moderately-large systems, whereas very large systems (say, of dimension larger than 10,000) must be solved interactively. Since CM very often leads to very large algebraic systems of equations, iterative linear solvers are extremely important in this domain. Effective iterative schemes exploit the special structure of the matrix A, such as symmetry and sparseness. Iterative methods for the solution of $Ax = b$ started to appear in 1950, with me invention of the method of *Krylov spaces* and the method of *Conjugate Gradients* by Hestenes and Stiefel for symmetric matrices. Since then these methods have been improved significantly, and many new iterative methods have been invented, such as *GMRES* by Saad and Shultz (1986) for non-symmetric matrices, which is widely used today in CM applications.

3. Algebraic Eigenvalue Solvers


C. Lanczos

Both the standard eigenvalue problem $Kd = I..d$ and the generalised eigenvalue problem $Kd = JMd$ occur often in CM, e.g., in free vibration or buckling analyses. Often the matrices K and M are large and sparse. .

A powerful method that solves both types of problems had been devised in 1950 by Lanczos . About ten years later, J.G.F. Francis developed the now well-known *QR algorithm* for computing eigenvalues. During the 60's and 70's the QR method dominated the field, because in contrast to the Lanczos method which was invented to compute a few extreme eigenpairs, the QR method finds all the eigenvalues of a reasonably small matrix almost as fast as a few.

However, since the 80's, when large eigenvalue problems started to attract attention in CM, the Lanczos algorithm had a glorious "come-back" because it was particularly appropriate for such problems, and enabled the efficient computation of a small portion of the eigenmodes

4. Matric Decomposition Methods

Many algebraic solution techniques (for both linear-system solvers and linear-eigenvalue solvers) in use today are heavily based on matrix decomposition (or factorisation), namely on the ability to express a matrix as a product of simpler matrices.
The simpler matrices may be diagonal, triangular, symmetric, skew-symmetric, orthogonal, etc.
In the context of CM, me decomposition often has a physical meaning as well. Examples include specral decomposition and polar decomposition.
The pioneer in this area is *Householder* that has shown, in a sequence of papers starting in 1951, why matrix decomposition is very useful and has developed factorisation algorithms.

A. Householder

5. Finite Difference Methods for Wave Problems

In the early days of CM, systems of ordinary differential equations emanating from (hyperbolic) wave problerms were solved by the classical Euler time-integration techniques. However, in the late 50's the CM community realised that special methods developed directly for wave problerms were in need.
Two early time-integration methods that are still commonly used today are the family of schemes developed by *Newmark* in 1959 for structural dynamics, and the *Lax- Wendroff* scheme devised in 1960 for the solution of 1st-order hyperbolic systems. Later many other schemes were proposed, with some improved properties. We mention for example the *Hilber- Hughes-Taylor* scheme from 1978 with improved numerical dissipation.
One important issue that arises in the computational solution of hyperbolic and parabolic- hyperbolic problems is that of discontinuity capturing, and especially capturing of shock waves. The classical finite difference methods could not resolve discontinuities properly. S.K. Godunov was the first to recognise the difficulty and in 1959 proposed, for problems in fluid dynamics, the now well-known Godunov scheme. This opened the way to various *upwinding* and *flux-splitting* schemes proposed by van Leer (1974, 1982), Steger and Warming (1979), Roe (1980) and others, which can be found today in many of the modern production codes. Related methods have been developed in the context of the Finite Volume Method and FEM as well.

6. Nonlinear Algebraic Solvers

Most problems in CM are nonlinear. Discretization in space and time leads to a nonlinear system of algebraic equations. When large-scale problems started to be considered when it was realised that classical nonlinear solvers, like Bisection, Secant or even Newton were either not powerful enough or were inefficient.
One important family of improved solvers is that of *Quasi Newton (QN)* schemes. The first QN method was suggested by *Davidon* in 1959, and was later publicised and improved by Fletcher and Powell.
A QN method which became famous was the BFGS scheme which was developed in 1970 independently by Broyden, Fletcher, Goldfarb and Shanno.
A totally different approach to nonlinear problems with nonlinearity of a non-monotone nature is represented by *Arclength* methods (called 'continuation methods' by mathematicians). The first Arclength methods in the context of CM were proposed by G.A. Wempner (1971) and E. Riks (1972).

7. Fast Fourier Transform (FFT)

Spectral methods in CM often rely on the discrete Fourier transform. The most important step in this context is the calculation of the first N Fourier coefficients of a function when its values at N points are given.
A straight forward calculation of the Fourier coefficients requires $O(N^2)$ floating-point operations. The FFT is an algorithm for doing this calculation with only $O(N \log N)$ operations.
The FFT method was invented in 1965 by.W Cooley from IBM and J.W Tukey from Princeton University and AT&T Bell Labs. The method had an enormous impact on signal processing, as well as to CM and other branches of computational science

J. Tukey

8. Nonlinear Programming

The Simplex method appearing in the Dongarra-Sullivan list is a very well-known algorithm, invented by G. Dantzig, for linear programming, namely for optimisation problems with linear objective function and linearinequality constraints. However, most optimisation problems encountered in CM are associated with nonlinear objective functionals.

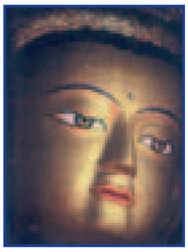
On the discrete level, the simplest problems of this type are *Quadratic Programming (QP)* problems, with quadratic objective function and linear constraints. Such problems arise in various fields of CM, including elastic contact and plasticity. This class of problems is also very important because the solution of more complicated problems can be approached by considering a sequence of QP problems.

Early work on Nonlinear Programming is due to Goldfarb (1969), Murtagh and Sargent (1969), McCormick (1970), Fletcher (1971) and Murray (1971). Methods for large scale optimisation (variations of which are used today in some optimisation packages) are due to Griffith and Stewart (1961) and Murtagh and Saunders (1978).

9. Soft Computing Methods

Traditionally, CM has been based on 'rigorous' classical mathematical procedures that draw on PDE theory, theoretical mechanics, numerical analysis, functional analysis, etc. However, since the early 80's new families of computational methods, which are sometimes collectively termed "soft computing" methods, have been applied. These types of schemes are based on a heuristic approach rather than on rigorous mathematics and draw on concepts of Artificial Intelligence (AI). Despite the fact that these methods were initially received with suspicion, they have turned.out in many cases to be surprisingly powerful, and their use in various areas of CM keep increasing. Three main techniques are Neural Networks, Genetic Algorithms and Fuzzy Logic. All three can be thought of as general optimisation techniques, but they are based on totally different methodologies.

Buddha



Traces of soft computing ideas can be found already in the 40's. Pioneers include McCulloch and Pitts in Neural Networks, Holland in Genetic Algorithms and Zadeh in Fuzzy Logic - although some claim that Fuzzy Logic was invented by Buddha! In the 60's and 70's the area was advanced by computer scientists, but only since the early 80's application of soft computing methods in CM have started to appear.

10. Multiscale Methods

Many problems in CM involve more than one length scale. Moreover, in some cases the different length scales interact with each other in a complicated way. This may occur in two levels: the physical level, where the phenomenon under consideration involves both a micro scale and a macro scale (two examples are aeroacoustics and fracture mechanics), and the numerical level, where poor resolution in one scale causes the deterioration of accuracy in another scale. Methods that address these issues are collectively called Multiscale Methods.

One famous multiscale technique is the *Muitigrid* method which can be thought of as an iterative linear algebraic solver requiring only $O(N)$ operations. The chief inventor is A. Brandt, in 1977.

Another approach is that of *Wavelets*, which, like simple sines and cosines, constitute building blocks of general functions, but are local and have special translation and dilation properties which allow them to resolve different scales. Wavelets have origins in 1909 (in the thesis of A. Haar) but were formulated in the way familiar today in 1985 and later, by each of S. Mallat , Y. Meyer and I. Daubechies. Research in Multiscale Methods is still very dynamic.

T.R.J. Hughes

I. BabuÓka

T.J. Oden

To end on a futuristic note, let us mention, in the context of FEM, the very recent Variational Multiscale method proposed by T.J.R Hughes, the Partition of Unity Method of J.M. Melenk and I. BabuÓka, and the Hierarchical Modeling approach of J.T. Oden's group. All these methods are very promising but are still evolving and only time will tell what impression they will leave on CM. ●

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Parameter Identification by Inverse Analysis in Structural Mechanics

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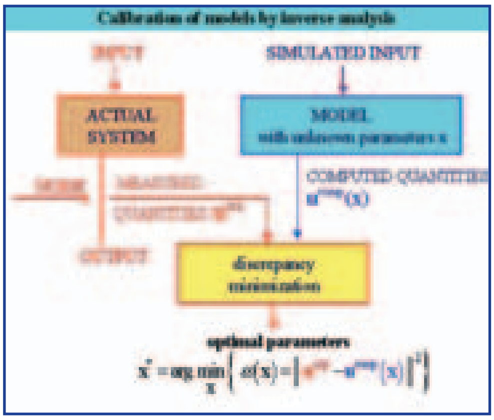
> *"... modelling means ... from the physical world to the world of simulation and back again to the physical world ..."*

At present inverse problems arise more and more frequently in technologies and engineering sciences, sometimes as real challenges to computational mechanics and to other disciplines. A general motivation might be expressed by words of great scientists. John von Neumann wrote that: "the sciences mainly make models; by a model is meant a mathematical construct which describes observed phenomena; the justification of such a mathematical construct is solely that it is expected to work". A warning on the importance and difficulty of the generation of models which can be "expected to work", is provided by other memorable citations: "modelling is the art of contriving from imagination; it involves a heroic simplification in order to grip the essentials" (M. Kac and S. Ulam, in "Mathematics and Logic"); "solving is an established art; formulation is still a mystery, relegated to the process of creativity", (T. Saaty and J. Alexander, in "Thinking with Models"); "the test: 'do we, or do we not, understand a point in physics?', is: 'can we make a mechanical model of it ?' " (Lord Kelvin); and finally: "all models are wrong, some models are useful" (George Box).

Computational mechanics represents a milestone in the history of sciences because it provides tools apt to make models of nature useful and "working" in von Neumann sense, namely predictive in quantitative terms. Modelling natural phenomena means to interpret and simulate the reactions of physical systems to external actions, i.e. the links between some causes and their effects: these are the purposes and role of "direct" analysis in computational mechanics. However, in real-life engineering situations, direct analyses often require preliminary "inverse" analyses, which go from effects to causes through the same model: in fact, as models become more and more sophisticated, less susceptible to specific measurements become the parameters involved in them as input apt to quantify some features of the considered system (e.g., material properties). Richard Feynman's celebrated motto, "garbage in, garbage out", holds not only for computers but for models as well.



Even if restricted to parameter identification in structural mechanics, the calibration of mathematical models of physical systems involves a number of diverse disciplines: experimental mechanics, for the selection (or production) and use of suitable equipment and for the assessment of measurement accuracy; mathematical modelling, which means to understand and describe physical laws, generate the relevant computational tools, such as finite element discretizations and computer codes and to assess modelling errors; sensitivity analysis needed to quantify the influence of the sought parameters on measurable quantities, and to design the experiments; mathematical optimization and relevant algorithms for numerical solutions; statistics, dealing with random noises which affect the experimental data, and with their possible consequences on the resulting estimates.

Central to inverse analysis is the "discrepancy" minimization with respect to the parameters to identify within the model adopted to simulate the test on the monitored system. Discrepancy function means here a suitably chosen norm of the differences between experimental data and their computed counterparts, the latter obviously depending on the sought parameters. In mathematical terms, this minimization problem frequently exhibits some (or even all) of the following rather unusual features: inequality constraints; large-size; non-convexity; non-smoothness; ill-posedness in Hadamard sense; multiple solutions or non-existent solution; solutions very sensitive to data perturbations.

Some of the many contributions to the theory and to the numerical methodology of the above kind of optimization problems (arising in diverse contexts, from mechanics to econometrics and game theory) can be regarded as milestones in applied mathematics of the last six-seven decades, such as: George Dantzig's mathematical programming; John Nash's mathematical programming "under equilibrium constraints"; Tikhonov regularization; Kalman filters.

Parameter identification problems are formulated basically by three approaches: the least-square "batch" approach, in which the available experimental data are exploited all together and the measurement uncertainties are accounted for merely by using the inverse of their covariance matrix to define the discrepancy function (so that more "weight" is attributed to more accurate data); sequential exploitation of data and of their inaccuracy statistics, starting from an "expert's estimation" and leading to estimates of the parameters and of their variances and covariances; Monte Carlo methods, centered on statistical evaluations of a set of estimate vectors generated by repeated inverse analyses with random inputs, in accordance with the scattering of the experimental data.

Broad is the spectrum of techniques employable for the numerical solution: first–order algorithms, like Sequential Quadratic Programming and "Trust Region" technique; zero-order ("direct search") procedures, such as Nelder-Mead and Complex; genetic algorithms, possibly made "hybrid", i.e. combined with a first-order algorithm in a late stage of the minimization process; artificial neural networks for inexpensive routine applications; methods based on Monte-Carlo approach, but apt to mitigate its computational burden by bounding techniques; Kalman-Bucy filters, sometimes with "global iterations" and with its recent improvement called "unscented".

In what follows some applications of inverse analysis are concisely outlined, with the severe limitations to structural mechanics, to static external actions (not dynamical excitations like in many other cases) and to some results of the writers' research. The objective pursued is merely to evidence, despite the above severe limitations, the multiplicity of possible practical uses of parameter identification methods, from civil engineering of large structures down to micro-technologies. References [6, 11, 12] can be regarded as representative of the several survey nowadays available in the literature.

In practical applications of inverse analysis, computational mechanics integrates experimental mechanics in a synergistic fashion. However, in "a priori" validations of novel identification procedures, computational mechanics plays a double role. In fact, in order to validate a new procedure: first, reasonable values are attributed to the sought parameters and are input into the model for direct analysis, in order to compute measurable quantities; second, these quantities ("pseudo-experimental data") are used for inverse analysis, whose resulting estimates are compared to the earlier assumed values, which should be recovered if the procedure works.

(a) Many existing dams, designed several decades ago, are deteriorated due to past extreme loads, like exceptional floods or earthquakes, and/or by slow processes, like alcali-silica reaction or orogenetic motions in the surrounding geological masses. Deterioration affects structural safety, since it means correlated reductions of both material strength and stiffness; in diagnostic inverse analyses, the possibly reduced Young modulus is traditionally regarded as the main parameter to identify in its present distribution over the dam. Clearly, this distribution can be assumed as zone-wise uniform, like in *Fig. 1* where 10 zones are chosen in a arch-gravity concrete dam and specified by colors.

The conventional monitoring system in large dams (consisting of pendula and collimators) is likely to be integrated in the near future by radar instrumentation, placed downstream at some distance and apt to map and measure in its direction the field of displacements on the dam surface. Thus the amount of available experimental data is greatly increased with respect to the one achievable by classical monitoring. As shown in *Fig. 2*, this growth much improves the estimates, in terms of mean values and standard deviations, when random "noise" affects the pseudo-experimental data consistently with the measurement errors (details in [1]).

The moduli estimation is here performed with the following features: test by hydrostatic load, due to seasonal changes of reservoir level; finite element model with linear isotropic elasticity assumptions; thermal effects allowed for, on the basis of temperature variations measured by internal thermometers; least-square formulation and solution by trust region algorithm; Monte Carlo statistical analysis.

(b) Overall diagnoses like the one outlined in (a) are usually unable to identify damages in lower zones near the foundation. Such expected limitations, which can be quantified by the estimation uncertainties *(Fig. 2)* and/or by sensitivity maps *(like that in Fig. 3)*, make local

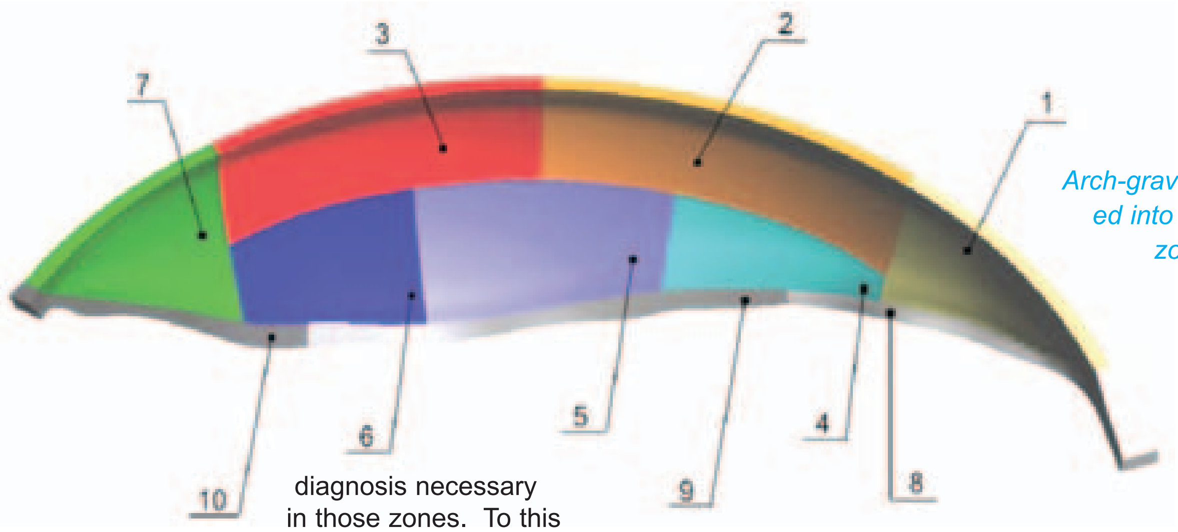


Figure 1:
Arch-gravity dam, sub-divided into ten homogeneous zones with unknown Young moduli to identify, from [1].

diagnosis necessary in those zones. To this purpose the integration of traditional local in situ tests and computational mechanics is likely to foster remarkable meaningful advantages (some details in [10, 11] and in related papers to appear).

In particular, flat-jack tests may be re-organized and associated with finite element modelling, inverse analysis and artificial neural networks. The neural networks are properly trained, preliminarily, once for all, in a computing center. The novel technique can provide, economically in situ, much more information than the usual tests, namely: normal and tangential stresses; Young moduli (in anisotropic situations) and shear modulus; tensile strength and fracture energy *(Fig. 4)*. Similar innovative developments, now in progress, concern also in-depth local tests, like parallel hole drilling and dilatometric measurements.

(c) Experimental information derived from in situ measurements are often integrated by tests performed in the laboratory on specimens extracted from the structure. Wedge splitting tests, see *Fig. 5*, represent alternatives to traditional three-point-bending tests, particularly for dam concrete with large aggregate size. These fracture tests have been computer-simulated by means of a finite element space discretization and by a mode I cohesive crack model, with a bilinear softening branch relating tractions to displacement discontinuities, characterized by four parameters to identify. By such modelling the direct analysis is amenable to a Linear Complementary Problem, and, hence, the least-square inverse analysis to a Mathematical Programming under Equilibrium Constraints, like in [9] for plasticity.

Figure 2:
Standard deviations of Young modulus estimates in the 10 zones of the dam, with traditional (circles, with confidence intervals) and with radar monitoring (crosses), by Monte Carlo procedure based on 250 inverse analyses.

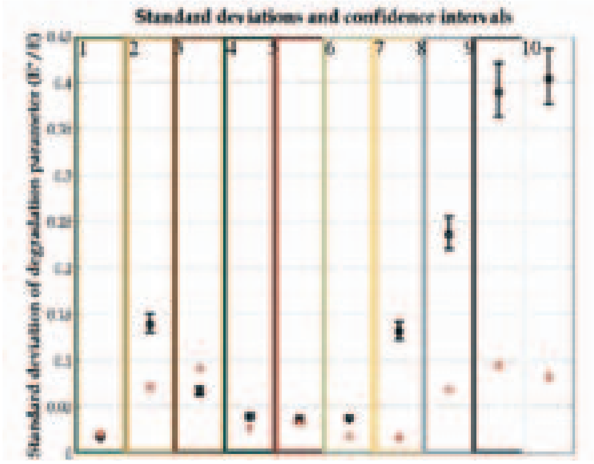
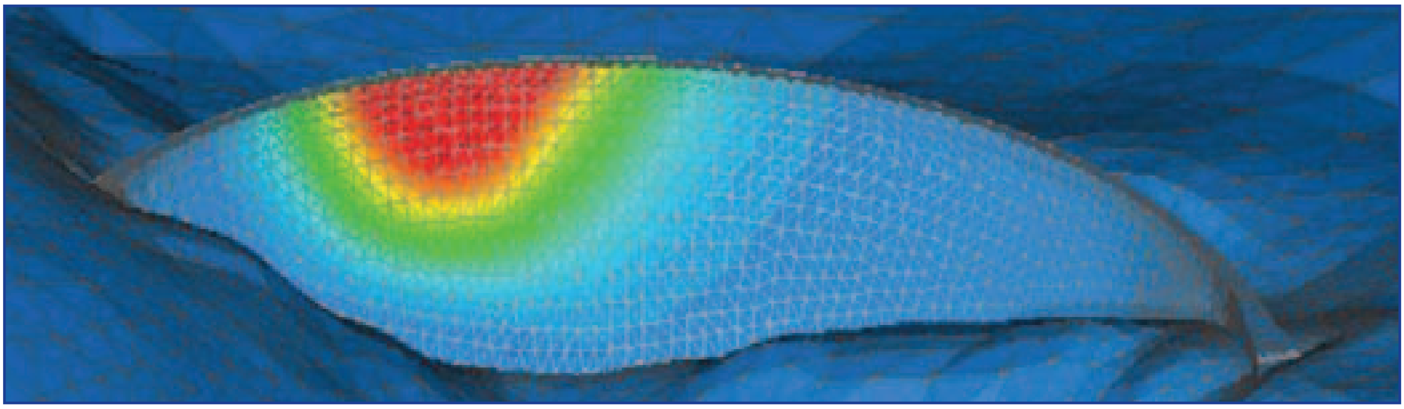


Figure 3:
Non-dimensional sensitivity maps of the displacement field with respect to the Young modulus of zone 3 (dam center, high).



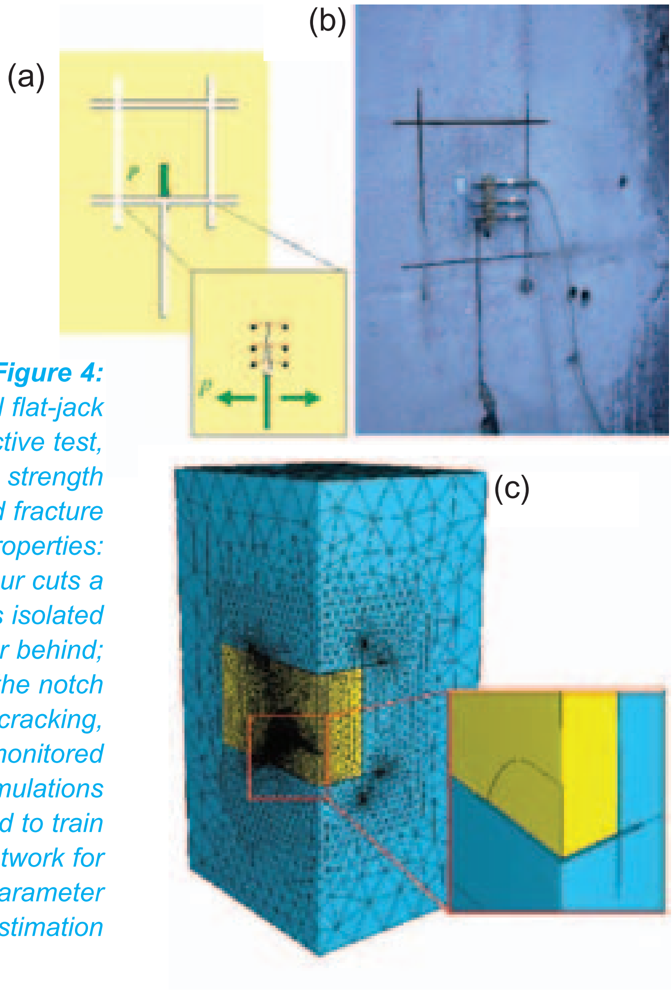


Figure 4: *A novel flat-jack non-destructive test, apt to assess strength and fracture properties: (a) by four cuts a specimen is isolated except for behind; a flat-jack in the notch induces cracking, which is monitored (b); FE simulations (c) are used to train a neural network for material parameter estimation*

The horizontal splitting force applied by the wedge, and the relevant crack opening displacement are measured during the test and are available for identification purposes. In [3] the inverse problem of material parameter identification has been solved, in a statistical context, by the extended Kalman filter technique, namely by updating sequentially, along the flow of experimental data, the mean values of parameter estimates and their covariance matrices which quantifies their uncertainty, as visualized in *Fig. 6.*

Figure 5: *Wedge splitting test performed on a small specimen (courtesy of V. Saouma)*

On the filtering sequential methodology the following remark by A.V. Balakrishnan (in "Mathematical Intelligence") is worth noting: "Kalman filter application does not mean merely putting numbers into formulae; indeed it requires no less than a case study". Perhaps essential features of this methodology are somehow poetically reflected in the words of Rudolf E. Kalman himself, when he compared it to the "filters of the mind", which interpret new data in light of pre-conceptions from the past, like President John Kennedy's way of thinking and deciding based on "selective perception".

(d) The inelastic properties of steel may be altered by the fabrication process and, hence, are frequently assessed by cyclic tension-torsion tests on small tubular specimens, with thin walls in order to achieve uniform distribution of strain in them. With cylindrical (not hollowed) specimens the strain field is no longer uniform, so that inverse analysis (simple because of axi-symmetry) becomes necessary to identify hardening parameters but practical advantages are achieved: cheaper and smaller specimens; less-destructive and more local tests.

To an industry which produces wheels for high speed trains, an inverse analysis technique was proposed [7], based on two stages: evolutionary genetic algorithm (zero-order) followed by a first-order gradient solver toward the absolute minimum of discrepancy, see *Fig. 7*.

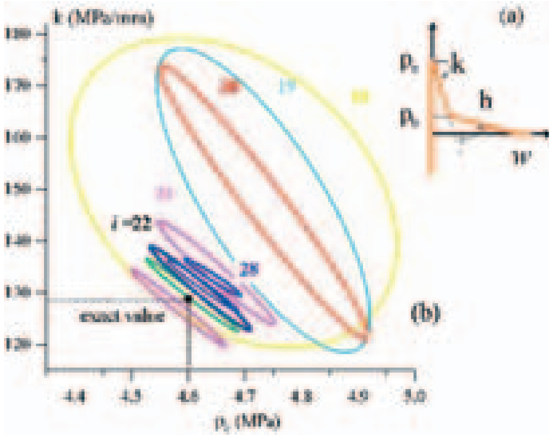


Figure 6: *Sequence of uncertainty domains of the estimated tensile strength pc and slope k of the first linear branch in a cohesive bilinear model (a), in a Kalman filter process, along the flow of measurement instants i: the centers of the ellipses shift toward the correct values of parameters, and their areas, proportional to the determinant of the current covariance matrix, decrease as more data are processed (b),from [3].*

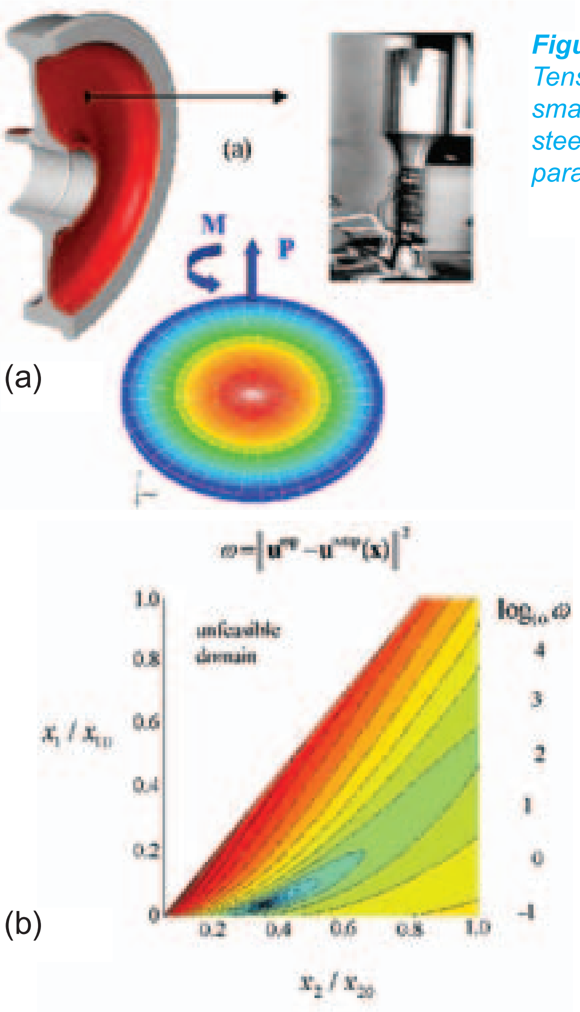


Figure 7:
Tension-torsion tests associated to inverse analysis, on compact small-size specimens extracted from different locations of steel wheels (a); map of the discrepancy as function of plastic parameters in Chaboche model (b), from [7].

(e) Structural mechanics and engineering concerning composite materials require material modelling at two scales: locally for each phase; globally in terms of average stresses and strains. At the latter, large scale the (usually anisotropic) constitutive model is often chosen by the engineer for structural design, with suitable parameters. Such parameters are identified by means of average strains generated by given average stresses either through laboratory experiments or, much more economically and faster, through computational homogenizations (details in [4]).

(f) Industrial processes for the production of composites sometimes alter the material properties of the individual phases. Parameters which quantify such local properties can be advantageously identified on the basis of traditional tests on usual specimens (in average stress and strain terms, see *Fig. 8*) and by an “inverse homogenization” method, like that proposed in [8], instead of performing difficult tests at the microscale.

g) Indentation tests are at present frequently employed for the calibration of material model at different scales, primarily at micro and nano scales. The indentation curve (namely, the relationship between applied force and penetration depth, *Fig. 9(a)* provides experimental data for parameter assessment through traditional semi-empirical formulae or, in recent times, through simulation of the test and inverse analysis.

A recently proposed technique combines the traditional indentation test with the mapping (e.g. by atomic force microscopes) of residual deformations, *Fig. 9(b)*, thus providing experimental data which allow through inverse analysis to calibrate both isotropic inelastic material models in more accurate fashion and also the anisotropic ones [2,5].

Such new methodology can be employed as well for the identification of bi-dimensional states of stress, in particular residual self-stresses generated by fabrication processes. In fact the imprint generated by an axi-symmetric indenter may not exhibit axial-symmetry in presence of the residual stresses, *Fig. 10(b)*: it directly reflects all features of such stresses and turns out to be crucial for their identification, whereas traditional indentation curves are insensitive to the direction of pre-existing bi-dimensional stress states.

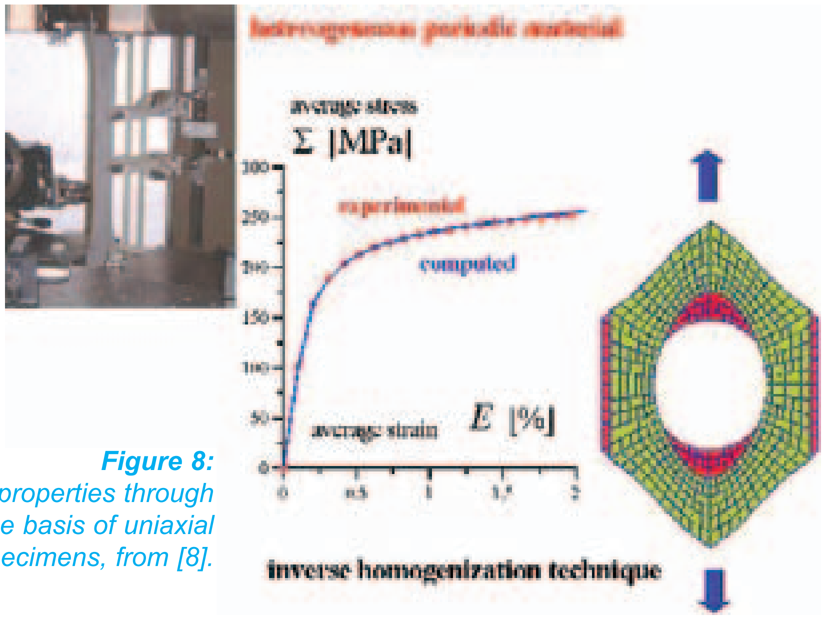


Figure 8:
Identification of local steel matrix plastic properties through inverse homogenization technique, on the basis of uniaxial tests at the macroscale on perforated specimens, from [8].

Three-dimensional finite element simulations are performed in finite-strain regime for these inverse analyses, particularly of functionally graded materials. Current research on the methodology which combines indentation, imprint mapping and inverse analysis concerns the following items: identification of material parameters and residual stresses in coatings; film- substrate interface properties and their effects on possible delamination phenomena; use of artificial neural network to be trained once for all through finite element test simulations and to be employed routinely as software accommodated in the laboratory experimental equipment, together with the indenter and a profilometer for imprint mapping; inverse analysis based on in situ hardness tests and imprint measurement only (no indentation curve) performed either in situ or in the laboratory where its geometry are brought by a mould.

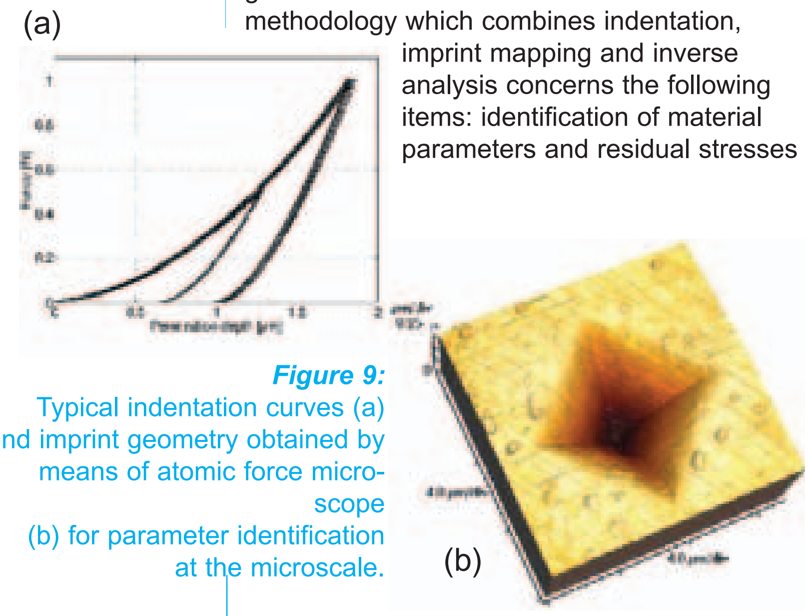


Figure 9:
Typical indentation curves (a) and imprint geometry obtained by means of atomic force microscope (b) for parameter identification at the microscale.

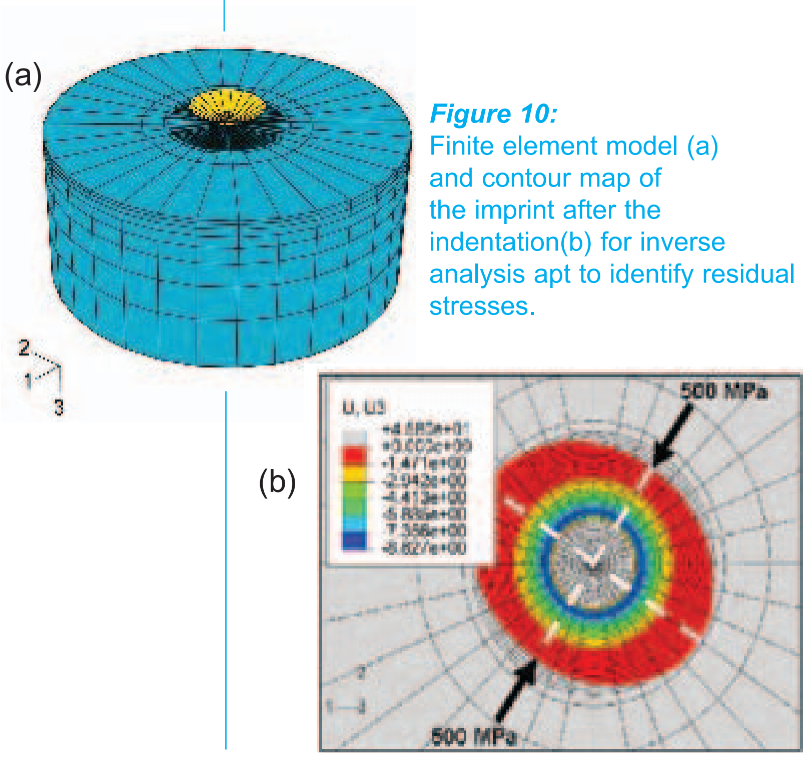


Figure 10:
Finite element model (a) and contour map of the imprint after the indentation(b) for inverse analysis apt to identify residual stresses.

The above small sample of briefly outlined parameter identifications with statical external actions, might hopefully evidence the growing importance of inverse analysis in diverse scientific and technological fields and in computational mechanics.

A critical remark was recently expressed by a material scientist: "the increasing popularity of inverse techniques to determine model parameters of a material, indicates that the scientific community is rarely attracted by the understanding of the basic mechanical properties of that material". Such worry should be kept in mind by computationally mechanicists.

Actually, modelling means to go "from the physical world to the world of simulation and back again to the physical world" (Karl Pister). "Back again" means either productive engineering use or, preliminarily, model adjustment, sometimes as for a few parameters like in the preceding examples: adjustment not by trial-and-error (which "may cause irreversible damages in the analyst's brain", according to P. Ibanez), but through experiments and inverse analysis combined for parameter identification: "a pleasant model may be right or wrong; the experimenter is the only one to decide and he is always right" (A. Einstein) ●

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Scientific Computing with Software-Components

by
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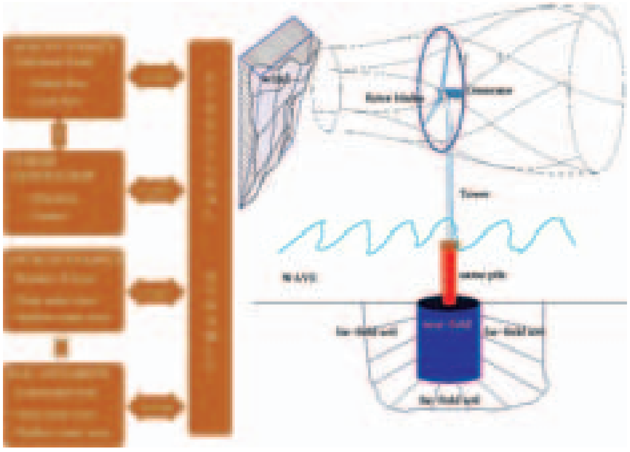
Introduction

In many cases of current interest, one desires to do a simulation of a complex system, actually consisting of several subsystems. By this is meant that several different scientific disciplines have been involved in the formulation of the total problem. After a formulation and mathematical model of the whole system has been found, it will usually be necessary to do a numerical simulation, and may be further manipulations such as optimisation, identification, optimal control, etc. As an example we shall here consider the simulation of an offshore wind turbine. The background is that for the fatigue evaluation of such a turbine, a time domain simulation is often performed with (pseudo)-random input from the environment, here wind and waves. Wind turbines behave sufficiently nonlinear such that simple linear frequency domain approaches do not work accurately enough here.

Such simulations have to cover a significant real time interval due to statistical reasons, and the computational models may need additional special treatment like model reduction, see for such an approach for a land based wind turbine. This model reduction aspect, while always important and helpful, will not be the main point of discussion here. Rather, we want to focus on the fact that such a (Monte Carlo) simulation requires a fair number of subsystems to describe the whole model. In our case these are (see Fig. 1)

- the turbulent wind field
- the aerodynamics of the wind turbine blades
- the blade structure, as well as the nacelle and tower, and foundation (in our example a mono-pile)
- the drive train
- the power generator
- the control system
- the random ocean wave environment (this actually will involve several subsystems)
- the hydrodynamic-structure load calculation
- the near-field soil domain
- that far-field soil domain

Figure 1:
The Components of the whole System



Each simulation is evaluated statistically (in this case via rain-flow counting) to obtain a statistically significant average result of the fatigue loading at a certain operating condition. These then have to be weighed according to their frequency of occurrence at a specific cite to obtain the total fatigue loading. Here we shall concentrate on the question of how to actually perform the simulation on a computing system.

Each of these subsystems has usually been described by its own mathematical model, and implemented into software separately. Thus to run the whole model, one could either design a new software system incorporating all of the necessary modelling, or one could try and use the already existing parts. The first approach is labelled as monolithic, and the second as partitioned. The monolithic approach is often not economically viable, and often also not desirable due to software engineering and management considerations. Also there is often considerable investment in existing software, which one would hope to recoup via the partitioned approach, which is therefore often favoured by many groups working on such coupled problems. There is certainly additional mathematical and numerical questions involved in such an approach, see for example and and the references therein.

The Multi-Physics Formulation

Here we will shortly describe the mathematical model and numerical solution method for each of the domains involved in the whole model.

Turbulent Wind

The wind field is separated into a mean wind field, which has a certain height profile, and a purely random (zero-mean) turbulent part. The turbulent wind field is assumed to be described well enough by a spectral model, as well as spatially homogeneous correlation functions. This allows for a purely frequency and wavenumber domain description with subsequent Fourier transformation into the time-space domain. This component is then added to the purely deterministic wind field. Numerically this is performed by sampling in the frequency-wavenumber domain and fast Fourier transforms (FFT), a standard and fast numerical procedure.

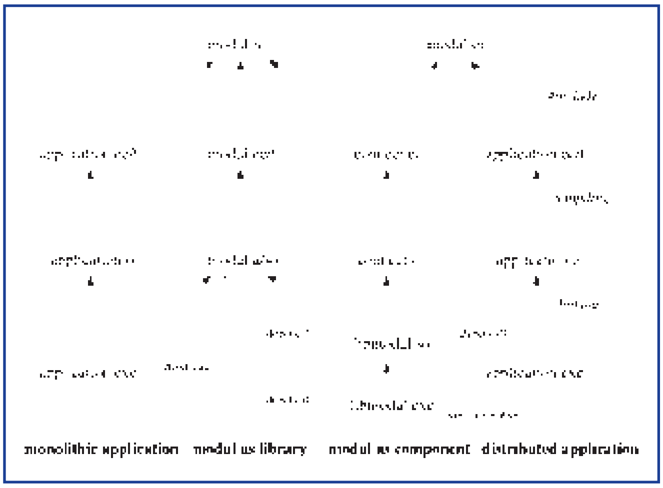


Figure 2: *Monolithic Linkage versus Component Linkage*

Wind Turbine Aerodynamics

The aerodynamics of the wind-turbine is very complex, and it is hard to find general models which do not involve a full Navier-Stokes description and subsequent very costly simulation - something that is presently not feasible for such a Monte Carlo simulation. Here a much simpler description is used, which nevertheless has been found to be sufficiently accurate for the purpose considered here. It is the so-called blade-element-theory. This is a simple consideration of momentum and angular momentum in concentric layers of the rotor disk. In this way one may compute the aerodynamically induced velocities, and hence the total interaction of the wind turbine with the wind field. This yields also the aerodynamic loading on the turbine, see and the references therein.

The Structural Subsystems

As most of the structural components are slender structures, or may be approximated as such, the structure is modelled as an assembly of nonlinear beams and rods with appropriate physical characteristics, see and the references therein. The numerical model then consists of appropriate nonlinear beam elements. Each of the substructures is modelled separately - i.e. each rotor blade, the nacelle, the tower, and the mono-pile - and joined through the correct coupling conditions.

Drive Train, Generator, and Control

Here standard models are used, which mathematically result in a coupled system of ordinary differential equations, which describe the dynamic behaviour of drive train and gear-box, power generator, and control systems - which usually acts both on the electrical components, as well as on the structure, e.g.by pitching the blades. These ordinary differential equations are integrated in time by again standard numerical procedures in the form of finite difference methods in time.

The Random Shallow Water Waves

Time accurate computation of random nonlinear shallow water waves as required here is a challenging task. Assuming the fluid to be inviscid and irrotational, nonlinear finite amplitude waves in a liquid body of finite depth are computed based on potential theory, i.e.the velocity potential must satisfy the Laplace equation at every instant in time. The free surface boundary conditions give a partial differential equation for the velocity potential and the free surface elevation on the free boundary. Similar coupling conditions are obtained at the boundary in contact with the deformable body.

During the computation, the repeated solution of Laplace's equation can be obtained by solving a boundary integral equation with the BEM and a fast multipole solver, see and the references there. The incident wave field is given by a stochastic wave process far from the structure, where the scattered (diffracted and radiated) wave field is comparatively small. This is finally coupled to another fluid description at the structure, which has a fully nonlinear description of both incident and scattered wave. The effect of the interacting flexible structure is included via a coupling computation. In between is another domain, which allows only waves to travel towards the wind turbine, and not the other way around, and thus effectively realises a silent boundary on the windward side - or more accurately in the direction of the incident wave field, which usually coincides with the windward direction - of the turbine. On the leeward side, an artificial beach is employed to realise the silent boundary at the other end.

The Hydrodynamic Load

As the wind turbine may be assumed as hydrodynamically transparent, there is no real interaction, but rather only action of the wave onto the structure. The load calculation has been performed by using the pressure computed from the above wave simulation, and by approximately adding local viscous effects.

The Soil

The mono-pile is surrounded by soil, and the soil-structure interaction has to be taken into account. The soil is considered in two parts. A near field part, where one may experience nonlinear behaviour, and a far-field part, where we are mainly concerned with the radiation of waves. The near field is numerically discretised with a standard nonlinear finite element model, and the far field is described by a boundary integral equation (BIE). This BIE in turn is discretised via the scaled boundary finite element method (SBFEM), see for details and references.

Software Architecture

The chosen software architecture allows a modular coupling concept reflected in the algorithmically strong coupling of the aerodynamics, the various fluid domains, the control system, the structure, and the soil. In many cases good problem-specific simulation codes already exist for the subsystems, into whose development much time and expert knowledge has been spent, and which should therefore be used also for the coupled computation.

In order to couple such simulation codes developed with the compiler languages used predominantly in scientific computations (FORTRAN, C, C++), the following two techniques are widely used:

- one executable generated by static or dynamic linkage of its modules, or
- separate executables, using explicit synchronous data exchange

The linkage of independently developed libraries leads often to naming conflicts or to problems like competitive signal treatment or incompatible memory management. The second approach requires for each new coupling constellation an insertion of communication calls into the respective program text, which usually presupposes the expertise of these codes.

The component technology offers a more flexible possibility to bring together program libraries in a larger application. Here the functionality of an existing or new library is described in an abstract interface. This is a middle-ware - called component template library (CTL) - which allows such coupling of otherwise independent software components, running on a distributed computer system. This is the main topic of this note. It may be added - but this will not be expanded upon here - that this kind of software architecture also enables a kind of coarse-grain parallelisation to be performed, where the parallel pieces are whole software components.

This kind of middle-ware has already been used successfully in an optimisation setting, see and , as well as in a micro-macro coupling for numerical homogenisation .

Software Components

The software components of the coupled system of an offshore wind turbine are implemented in the following ways:

- The random turbulent wind field is computed in MatLab, generating random aerodynamic loading for the rotor blades.
- The nonlinear structure is also implemented in MatLab as a FEM model, but some of computational parts are implemented with embedded C-functions. Also the control and generator systems are included with the MatLab functions.
- For the hydrodynamics part as a potential flow, first the random incoming waves are generated with MatLab functions. The boundary equations of the fluid domain is solved with a fast multipole method (FMM), the Fast-Lap-code which is coded in Fortran
- The soil dynamics is discretised in the near-field as a standard finite element model, and as a scaled boundary finite element (SBFEM) model in the far-field.

Figure 3:
Part of Discretisation of Water and Soil

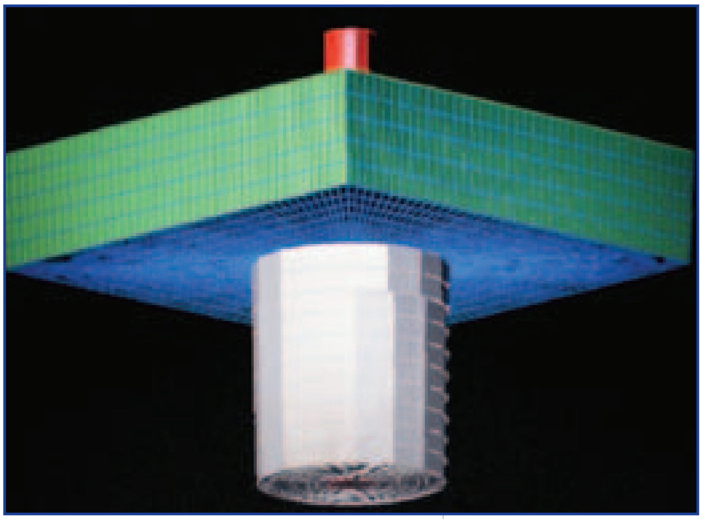
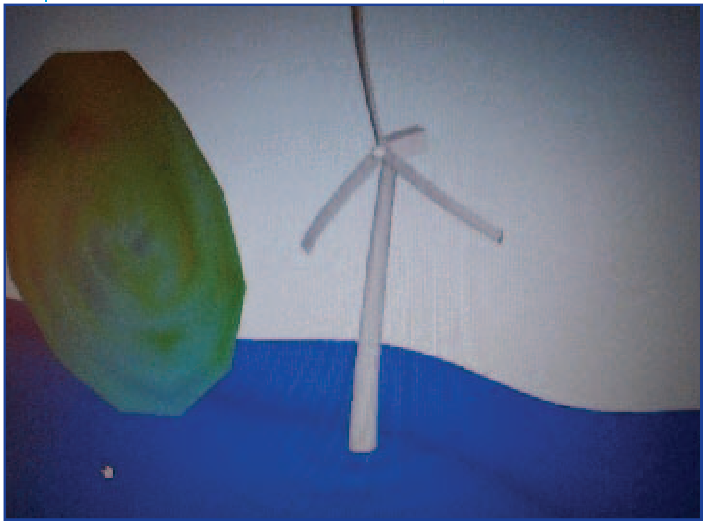


Figure 4:
Snapshot of the Wind Field, Waves and the Deformed



The FE-model in the near-field is solved with the Felt-code in C. The far-field is computed by the SBFEM-code in Fortran
- As some part of the computation are located on different computing platforms, the remote method invocation via CTL-interfaces is used as a middle-ware for the communication of all he component software

The control instance of the overall time loop is also implemented in Matlab.

Idea of Software Components

Many modern applications are in need of a decent distributed object framework, such as CORBA or DCOM (Distributed Component Object Model, see [1]. Most of the existing solutions share the problem that they dump a significant amount of work on the application programmer and that they enforce a strict separation of distributed and traditional monolithic systems. These problems are addressed by the CTL C++ implementation (CTL/C++), which tries to make the development of distributed systems as easy as possible.

The Component Template Library (CTL)

The CTL is an implementation of the component technology. The main aspects, which are the basis for their design were

- covering the features of the programming language C++
- simple handling
- maximum de-coupling of the CTL components
- run time efficiency
- flexible employment of existing components

These design goals were reached on basis of the Meta Template programming with the introduction of abstract data types and by using a simple efficient protocol as well as by the availability of a multiplicity of communication/ connection variants.

> *" ... several different scientific disciplines ... involved in the formulation of the total problem ..."*

The Component Template Library (CTL) can be used to realize distributed component based software systems. In general, RMI is a mechanism which allows programs to make remote function calls and access remotely stored objects. The communication happens over a serialized byte stream, which can, for example, be transported with TCP/IP, between a client (the one who calls a method) and a server (the one who will execute it). Both sides have to share their knowledge about available classes, functions and methods, this is done in a component interface (CI), sometimes in a special language, like the interface definition language (IDL) of CORBA. Such a collection of related classes and functions and the way to interact with them is usually called a component. Ideally, the client-side application should not need to know if a certain component is available locally or will be invoked remotely. Of course, this means that there needs to be an authority which can provide information about available components to distributed applications, an example for this is the Object Request Broker (ORB), which handles Interoperable Object Reference (IOR; basically an URL for an object) of available components. The exchange of structured data types over a serialized stream has to be abstracted from their binary representation. In the CTL protocol, any complex data structure is a composition of simpler types, which can either be a fundamental type or one of a limited number of composites and to read a data structure from a stream only the binary representation is needed.

Generalisation of Linkage

One main concept of the CTL is a generalisation of linkage which gives an easy understanding of distributed applications.

In the monolithic case an application is build up by the linker from a list of objects and dynamic or static libraries. For each called function the compiler wants to see its declaration. After compiling the linker first looks in the given list of objects and libraries for an definition of the called function (using it's signature as an identifier) and then binds the call to exactly one implementation. In a list of objects such a definition may occur only once (otherwise multiple definition), in a list of libraries the first found implementation will be taken. If no definition was found, the error "undefined symbol" occurs.

In this case all listed objects and libraries must be available at linkage time on the compiling machine. Furthermore the set of used implementations is determined already at linkage time. While run time this implementation will be executed on the same processor in the same process as the calling function.

The Windows registry and the Unix/Linux dlopen mechanisms enable run time linkage. But also here only one implementation of a function can be used, the execution is still performed on the same processor and in the same process.

The CTL gives both, the selection of an implementation and the binding, in users hand. At run time it can (and must) be selected which implementation on which host to be linked in which mode. In the definition of the library (in this context called component) the binding of the function signature to an implementation must be given.

The *Fig. 2* shows the dependency graph during classical linkage (left) and component linkage (right). While in the first case the application depends directly on the used module, it depends in the second case only on the interface (modul.ci). Consequences of this are:

- The application does not have again to be recreated, if the module is modified.
- At run-time the application can decide, which components and how many instances of these components on which hardware to be used.

Distributed Application/ Hardware-Mapping

After building all involved software components they have to be mapped onto available hardware resources. Here the less time critical parts of the MatLab and the WKA code are placed together on one host machine.

The coupling with the FastLap code needs only the exchange of boundary data, so that was reasonable to place this component on another Linux server. The linkage type was a TCP/IP connection.

Due to the fact that the Felt2 code was only compilable on an SGI with more than four GByte RAM at the Institute of Applied Mechanics, this component had to be instantiated on that machine. Because there was a Fire Wall in between, a Security Shell (ssh) based linkage had to be chosen. The coupling of Felt2 code with the SBFEM-code needs intensive exchange of data, therefore the Similar component was located at the same machine.

Numerical Examples

The computational example has been investigated for testing the numerical algorithm and software component technology. The coupled system of an offshore wind turbine is solved. It involved the aerodynamics of the turbulent wind, the structural dynamic system of the turbine including the control and generator system, the hydrodynamics system of random waves and the soil dynamic system of the sea bottom. In order to achieve a more realistic computation, the unbounded soil is included here as mentioned before.

As the different subsystems require the different time interval for numerical stability, the simulation proceeds with the minimum time interval requirement (in this case the soil part) and then used it as the constant time interval for the entire system. However an adaptive control of time interval is also possible. The boundary meshes are used here for the water wave part, using FE-meshes for the soil at the near-field region and the boundary meshes for the far-field region as shown in *Fig. 3*.

In *Fig. 4* the characteristic of the random wind is shown which includes the wake effect. The fluctuation of random waves are presented below the turbine, the deformation of the free surface wave shows the natural sea-state and some effect from the structure can also be observed. The movement of the turbine can be seen in the middle of *Fig. 4*, it deforms very uncertainly as the wind and wave loading are random fields. The displacements of one blade are shown in *Fig 5.* ●

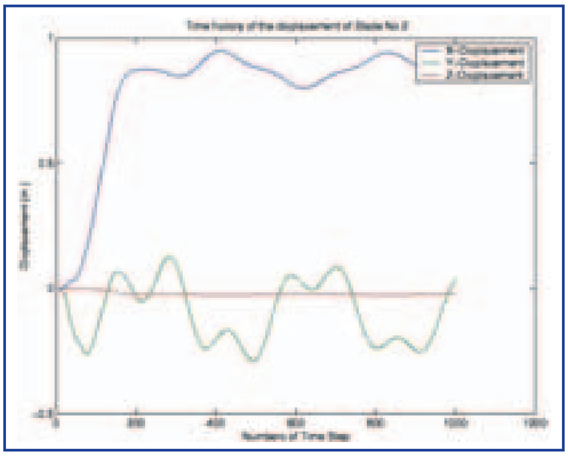


Figure 5:
The Displacement of one Blade

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Model Validation,

or how can one describe the Lack of Knowledge

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Model validation is becoming a rather hot topic, even if some people tend to say that a model can only be invalidated, but never validated. Much has been written on this controversial issue (see [- 5]). On the positive side, the word "validation" is used very often by engineers in the sense of a procedure, defined through practical rules and experiments, which ensures that the structure being designed will,once built, perform as expected. Where there is a lack of knowledge, safety co-efficients are introduced in order to guarantee conservative predictions. Thus, model validation in the context of "engineering reality" should be considered a real issue. The challenge is to go beyond the philosophical level and elaborate practical tools which can be applied to true engineering problems. Solutions are beginning to surface for very common models used instructural design. This short note aims to introduce and to illustrate them.

Verification is generally considered to be a related topic, which can be viewed as a subset of model validation using an intermediate, but perfectly defined, reference: the conceptual model. Thus, verification is a rather well-posed problem and an easier challenge.

Validation with respect to a particular set of experimental data

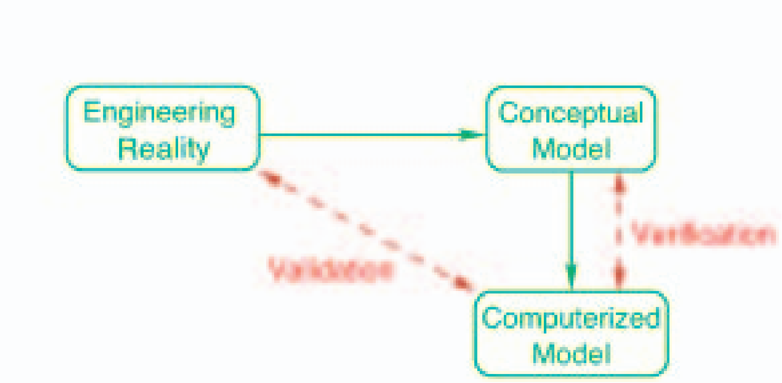
A first, restrictive problem is model validation with respect to to a well-chosen (but particular) set of experimental data, and the resulting updating of the model. Much work has been done in this area since 1980 and, today, there are some engineering tools available; the subject which seems to have seen the most progress is the updating of dynamic structural models (mass, stiffness, damping) in the low-frequency range (see [6,7]).

Many of the methods proposed do not attempt to provide meaningful error measures which could be used for validation: their only objective is updating. A first set of methods is based on the search for minimum norm corrections. A second set is closely related to control theory.

There are two main difficulties. First, the updating problem, like all inverse problems, is not well-posed and requires regularization. The second difficulty concerns the localization of the corrections: sensitivity techniques or the like are required to identify the most erroneous structural parameters. All these methods work well when a sufficiently large amount of experimental data is available, which is not always the case.

Let us also note that other difficulties could come from the measurements; an important practical issue is how to eliminate erroneous measurements due to human error.

Figure 1:
Model validation and verification



True error indicators in the framework of the Constitutive Relation Error (CRE) method were developed [7-9] in an attempt to overcome these difficulties. At the core of this approach is the question of the choice of the reference. In the CRE approach, the reference contains the “reliable” part of the model, e.g. the equilibrium equations. Only a subset of the experimental data - the reliable data - is part of the reference. Actually, two errors are calculated: the modeling error, and an error which characterizes the quality of the experimental data. The capability of this approach is illustrated below.

Figure 2 shows the structure being studied, a satellite support called SYLDA5, for which a FE model is available.

A preliminary step, called “recovery of the experimental results” was first performed using the error characterizing the quality of the experimental data. Erroneous sensors were localized, then corrected (if possible) or removed.

Next, the updating process, which is iterative, began. At each iteration, the most erroneous structural parameters were localized and corrected until the modeling error reached a threshold of a few percent. At the starting point, the modeling error was 12.39 %, which is quite significant; the updating process was carried out until the modeling error became reasonable, i.e. 2 or 3 %. After four iterations, the error was down to 2.27 %.

Table 1 lists separately the “total” modeling error, the modeling error of each mode, and the differences between the calculated and measured frequencies at each iteration. A much better fit can be observed after 4 iterations. One can also note that the calculated CRE-modeling errors on the modes are nearly identical to the errors on the frequencies, which are the differences Δf between the calculated and measured values.

Remarks:
A possible situation is that the modeling error does not decrease enough to reach the target; this means that the model is too coarse.

An additional development to include probabilistic models and noisy experimental data was presented in [10].

Figure 2:
The structure

Model validation: the real problem

The description of parameters such as material uncertainties is necessarily at the heart of any approach to the actual validation problem in the context of engineering reality. Probabilistic modeling has become increasingly popular [11]. There are also other approaches which do not involve probability laws,such as in [12-15].

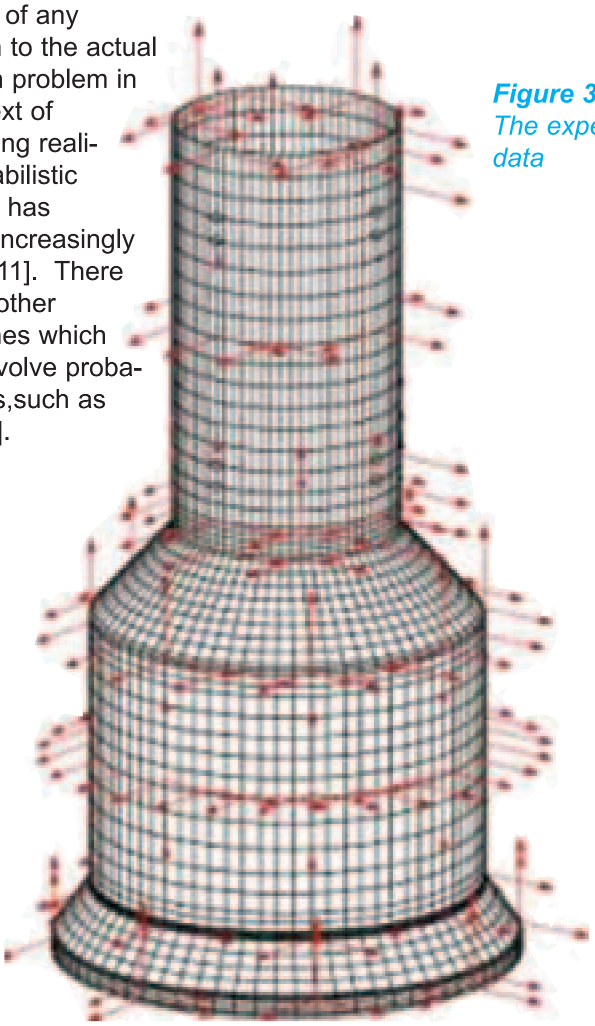


Figure 3:
The experimental data

Table 1:
Summary of the updating process. (+ : mode swapped with Modes 4 and 5)

Iterations	Initial			1		2		3		4	
Error (%)	E_{CRE}	Δf	MAC	E_{CRE}	Δf	E_{CRE}	Δf	E_{CRE}	Δf	E_{CRE}	Δf
Mode 1	3.45	-3.51	99.62	2.65	-2.69	0.24	0.28	2.05	2.05	1.67	1.86
Mode 2	3.25	-3.31	99.73	2.46	-2.49	0.39	0.37	2.19	2.15	1.54	1.43
Mode 3	5.10	-5.24	96.53	4.06	-4.14	0.40	-0.40	1.49	1.48	1.49	1.48
Mode 4	10.29	-10.85	99.11	9.78	-10.29	9.03	-9.48	4.09	-4.15	4.28	-4.22
Mode 5	9.86	-10.39	99.64	9.36	-9.83	8.61	-8.99	3.66	-3.75	3.76	-3.98
Mode 6	3.47	3.45^+	97.45	1.91	1.90^+	0.10	0.10^+	2.66	2.63	0.00	0.00
Mode 7	27.15	23.60	98.77	1.27	1.27	1.27	1.27	3.36	3.30	2.71	2.67
Mode 8	27.77	24.09	98.87	1.92	1.90	1.92	1.90	4.00	3.92	3.36	3.30
Mode 9	1.78	-1.79	96.14	0.09	-0.09	0.09	-0.09	0.02	0.02	0.10	-0.10
Mode 10	1.24	-1.24	95.84	0.44	0.44	0.44	0.44	0.55	0.55	0.43	0.43
Mode 11	6.41	*	*	1.01	*	1.04	*	2.11	*	1.65	*
Mode 12	4.82	*	*	0.64	*	0.63	*	1.36	*	0.56	*
(E_{CRE_T})	12.39			4.32		3.69		2.62		2.27	

> “ The challenge is to go beyond the philosophical level and elaborate practical tools which can be applied to true engineering problems. ...”

Here, we propose an approach, called the “theory of the lack of knowledge” (LOK), which attempts to give a pragmatic answer to the problem of model validation in the context of engineering reality. This could be viewed as an extension of the concept of safety coefficients [16-18].

For the sake of simplicity, let us consider a family of quasi-identical real structures whose environments are assumed to be well-known. Each of these structures is modeled as an assembly of sub-structures E (E , E) whose connections can be viewed as special substructures. This scale is assumed to be consistent with the outputs of interest chosen. We also assume that an elastic, deterministic FE model is sufficient to predict the response of the “structure” in the usual sense. The starting point of the lack-of-knowledge theory consists in associating with each substructure E a pair of scalar internalstate (m_E^- , m_E^+) called the “basic LOKs” such that:

$$-m_{\mathrm{E}}^-(\theta)\overline{\mathbb{K}}_{\mathrm{E}} \leq \mathbb{K}_{\mathrm{E}}(\theta) - \overline{\mathbb{K}}_{\mathrm{E}} \leq m_{\mathrm{E}}^+(\theta)\overline{\mathbb{K}}_{\mathrm{E}}$$

where $\overline{K}_E$ is the calculated stiffness matrix and $K_E(2)$ the stiffness matrix of an actual structure belonging to the family being studied. In this formal expression, the in equalities must be considered to hold for the eigenvalues.

The basic LOKs (m_E^+ and m_E^-) could take set values, but they usually follow given probability laws. This approach yields a new type of modeling of the family of actual structures being studied, in which one defines only the envelope of the actual responses. For an output of $\alpha(2)$ (FE value: $\bar{\alpha}$), one can calculate the effective LOKs such that:

$$-\Delta\alpha_{\mathrm{mod}}^-(\theta) \leq \alpha(\theta) - \overline{\alpha} \leq \Delta\alpha_{\mathrm{mod}}^+(\theta)$$

If the basic LOKs are small enough, this calculation is easy using linearization.

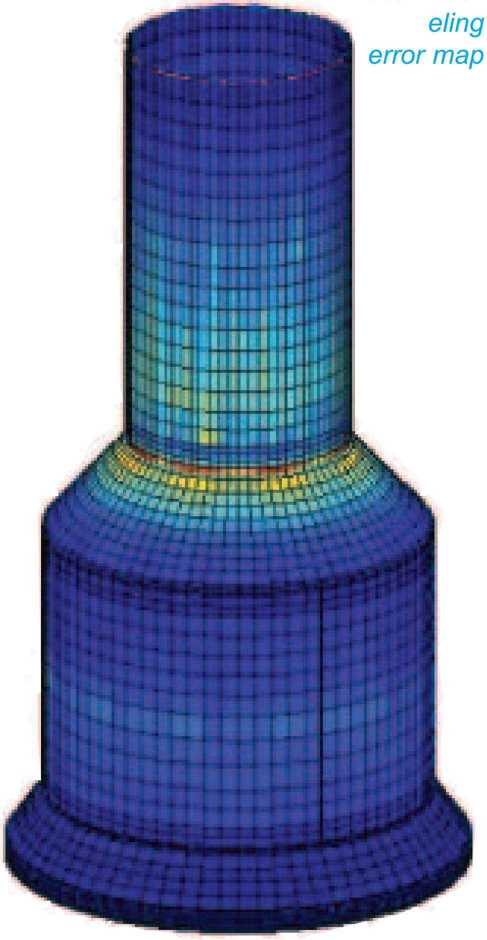


Figure 4:
Local modeling error map

With this theory, the central problem is the reduction of the basic LOKs using additional experimental information; the starting state could be an initial, overestimated LOK level obtained experimentally or through *a priori* knowledge. Let us assume that the additional test used concerns essentially Substructure E. The measured envelope should be included in the envelope given by the reduced LOK model.

The main question is, how close to one another are the two envelopes? The answer depends on the visibility of the LOK on E through the test: this is characterized by a coefficient of representativeness ρ_E , [0;1] which could be estimated by experience or through calculations if the causes of the lack of knowledge are known *a priori*.

Figure 5 and *Table 2* illustrate the LOK reduction process. Let us observe that even with poor knowledge of the ground it is possible to achieve rather good knowledge of the SYLDA5. ●

Table 2:
Reduced basic LOKs, 99% probability values

Substructures	Initial basic LOKs		Reduced basic LOKs
	$[-\overline{m}_E^{-0}, \overline{m}_E^{+0}]$	Laws	$[-\overline{m}_E^{-}, \overline{m}_E^{+}]$
SYLDA5	[−0.250; 0.250]	normal	[−0.016; 0.000]
Payload	[−0.250; 0.250]	normal	[0.000; 0.144]
Ground	[−0.750; 0.750]	uniform	[0.000; 0.435]
Connection	[−0.250; 0.250]	uniform	[−0.060; 0.000]

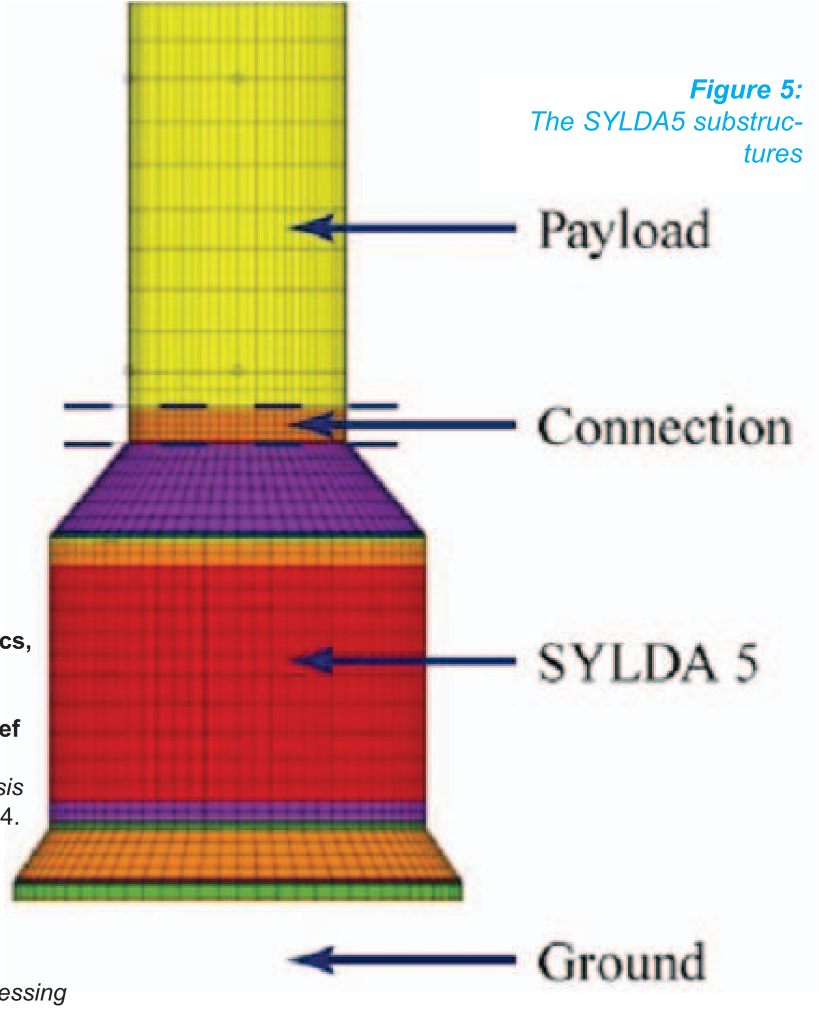


Figure 5:
The SYLDA5 substructures

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APACM NEWS

Asian-Pacific Association of Computational Mechanics

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IAPCOM'07 *in conjunction with* EPMESC XI
Third Asian-Pacific Congress on Computational Mechanics

in conjunction with

Eleventh International Conference on Enhancement & Promotion of Computational Methods in Engineering & Science

Kyoto, Japan - December 3-6, 2007

The Asian-Pacific Association for Computational Mechanics (APACM) and the Conference Board for the Enhancement and Promotion of Computational Methods in Engineering and Science (EPMESC) are pleased to announce that the third Asian-Pacific Congress on Computational Mechanics (APCOM'07) in conjunction with the Eleventh International Conference on Enhancement and Promotion of Computational Methods in Engineering and Science (EPMESC XI) will be held in Kyoto, Japan during December 3-6, 2007. The joint congress will feature the latest developments in all aspects of computational mechanics, with many other emerging computation-oriented areas in engineering and science. In addition to keynote lectures and minisymposia that highlight the trends in computational mechanics, numerous vender exhibits are planned.

APACM decided to hold the Asian-Pacific Congress every three years following the first congress (APCOM'01) held in Sydney in 2001. The second congress (APCOM'04) was held in Beijing in conjunction with the Sixth World Congress on Computational Mechanics (WCCM VI). On the other hand, the first EPMESC conference was held in Macao in 1985, and thereafter held alternately in Macao and a city in China, including Guangzhou, Dalian and Shanghai.

Figure 1: *Kiyomizu-dera*

APCOM'07-EPMESC XI will be held at the Kyoto International Conference Hall, conveniently located in downtown Kyoto, within 25 min by subway from Kyoto Central Station. Kyoto, surrounded by gracefully wooded hills and reflecting its 1200 years' history, was the capital of Japan from 794 to 1868 AD. In addition to beautiful imperial villas, Kyoto is home to about 400 Shinto shrines and 1,650 Buddhist temples which dot the entire city. Innumerable cultural treasures and traditional crafts, as well as beautiful spring cherry blossoms and autumnal colors, attract visitors to Kyoto, both from within and without Japan. Today, the city of Kyoto is also a bustling academic city that is young-at-heart, with nearly 50 institutions of higher education, and a home to many world-class corporate research giants. The spirit of Kyoto lies in its unique blend of old and new, taking the best of the old and applying them to the future. The congress period coincides with the perfect time for viewing the beautiful deep red hues of the Japanese maple's foliage.

Figure 2: *Kinkaku-ji*

Important Dates

Online submission of minisymposia proposals	August 1, 2006
Deadline for minisymposia proposals	December 1, 2006
Final selection of minisymposia	February 1, 2007
Online submission of abstracts	December 1, 2006
Deadline for abstract submissions	April 1, 2007
Final selection of abstracts	June 1, 2007
Deadline for submission of full length papers	August 1, 2007
Deadline for early registration	October 1, 2007

For further information please visit :
http://www.apacm.org/apcom07-epmescXI •

Report from

Japan Association for Computational Mechanics

USNCCM8

July 2005

On the occasion of **USNCCM8** held in Austin, Texas last July, the JACM meeting was held to discuss the prospects of JACM and to present the JACM awards. More than 20 members got together.

It was reported that the JACM organizes 7 minisymposia at **WCCM7**, Los Angeles this July. The progress of preparing **APCOM07-EPMESC XI** (http://apacm.org/apcom07-epmescXI) was also reported, showing its preliminary announcement.

The JACM Award for Computational Mechanics was presented to **Professor Y. Tomita** and **Professor M. Tanaka**.

The JACM Award for Young Investigators in Computational Mechanics was presented to **Drs. Taiji Adachi** and **Tomoshi Miyamura**. •

Figure 2:
Yoshihiro Tomita

Figure 3:
Masataka Tanaka

Figure 4:
Taiji Adachi

Figure 1:
JACM dinner meeting in Austin.

Figure 5:
Tomoshi Miyamura

MECOM 2005

VIII Argentinian Congress on Computational Mechanics

Buenos Aires, Argentina, November 16-18, 2005

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The VIII Argentinian Congress on Computational Mechanics took place in Buenos Aires, Argentina, from November 16th to 18th, 2005. Sponsored by AMCA, Argentine Association for Computational Mechanics, this edition of the regionally renowned MECOM series played somehow the role of a "birthday party" for celebrating AMCA´s 20th anniversary.

MECOM 2005 was organized and hosted by the School of Engineering and Sciences and the Center for Advanced Studies of Universidad Argentina de la Empresa (UADE), a non-profit private university. The responsibility of the organization rested mainly in the local organizing committee, composed by Axel Larreteguy (Chairman), Paola Dellepiane (Secretary), and Marcelo Raschi (Logistics), with the help of Sergio Idelsohn (AMCA/President), Lelia Zielonka (AMCA/Secretary), and many other people from the administrative sectors of UADE.

Besides the usual ordinary sessions on Fluid Mechanics, Solid Mechanics, etc., there were sixteen Invited Sessions, organized by researchers from Argentina and other American countries. The sessions covered a wide range of subjects, including Moving Interfaces, Water Resources, Environmental Engineering, Constitutive Modeling of Materials, Dynamic of Structures, Heat Transfer in Industrial Processes, Mathematical Aspects of FEM, Turbulent Flows, Atmospheric Dispersion Processes, Petroleum Reservoir Simulation, Automobile Industry, Distributed Computing, Biomedical Devices, and Space Technology. The invited session organizers were responsible for collecting and managing the reviewing process of about two thirds of the papers presented, thus playing a key role in the success of the conference.

There was also a special Poster Session, devoted to articles in which the first author was an undergraduate or a graduate student, with prizes for the best articles.

Among the national and foreign experts that attended the conference, it is important to highlight the names of the plenary speakers, which were Xavier Oliver (Universidad Politécnica de Catalunya, Spain), Miguel Cerrolaza (Universidad Central, Venezuela), Rainald Löhner (George Mason University, USA) and Kenneth Runesson (Chalmers University of Technology, Sweden).

The conference largely exceeded its original national scope, as papers have been received from many American and European countries. Most of the more than 300 contributions came mainly from Argentina, Brazil, Venezuela, and Chile, but some have also been received from USA, Spain, Uruguay, Ecuador, México, Canada, Italy, and Germany. More than 220 researchers and students shared knowledge and experiences in oral presentations that, due to the large numbers of contributions and the little time available, had to be organized in up to 5 parallel sessions.

The congress was a big success in terms of the number of abstracts received. Most of them were accepted and are collected in the Book of Abstracts, which is part of Vol. XXIV of the Mecánica Computacional Series edited by AMCA. The volume is completed with a CD that includes the accepted full papers.

MECOM2005 is now history, but it made its contribution to the never ending task of keeping the local and regional numerical community in touch and growing. It is time to look forward to ENIEF2006, which will most certainly success in continuing with this effort.. ●

Figure 1:
Participants at MECOM 2005

Figure 2:
Opening ceremony

Figure 3:
Poster session

Figure 4:
Profs S. Idelsohn, X. Oliver & C. García

Figure 5:
Lecture by R. Lohner

XV Congress on Numerical Methods and their Applications

Santa Fe, Argentina, 7-10 November 2006

AMCA, the Argentinian Association for Computational Mechanics announces the ENIEF 2006: XV Congress on Numerical Methods and their Applications, to be held at Santa Fe, Argentina, on November 7-10, 2006.

The local organization was given to the International Center for Computational Methods in Engineering (CIMEC), belonging to INTEC, which is an institute of the National University of Litoral (UNL) and the National Council for Scientific and Technological Research (CONICET), of Argentina.

The first ENIEF Congress took place in 1983. Since then fourteen ENIEF and eight MECOM (Argentinian Congress on Computacional Mechanics) has been organized by AMCA.

Topics

The conference topics include application of numerical methods in engineering problems, among them: Solid and fluid mechanics; Heat and mass transfer; Structural analysis; Bioengineering; Multiphysics problems, Multiscale modeling, Mesh generation and error estimation, Industrial and environmental applications; Mathematical foundations; Inverse problems and optimization; Software development; High performance computing.

Location

Santa Fe is one of the historic cities of Argentina. It was founded in 1573 by the Spanish conqueror (“Adelantado”) Juan de Garay, having at present some 400,000 inhabitants. Several examples of colonial architecture can still be seen like the “Convento de San Francisco”, with its remarkable museum and church. In front of them stands the important “Museo Histórico Provincial”. The ruins of “Cayastá”, are located at the place of the first foundation of this city, 80 km far from the present location. Santa Fe is surrounded by water (rivers and lagoons) and near the Paraná River, one of the broadest and longest rivers of the world. Sports, games, and social activities, are mainly related to rivers, including fishing. Fish is a well-known food specialty of the city.

Student Paper Awards

Following what was initiated in ENIEF 2004, a Poster Session will be organized for undergraduate students with awards for the best papers.

Instructions and deadlines

Participants should submit a one page abstract not later than April 15, 2006. Full papers will be received by July 15 and submitted to a reviewing process to be included in the proceedings. Submissions are accepted in Spanish, Portuguese and English.

Information

Web: **http://www.cimec.org.ar/enief2006**
E-Mail: cimec@ceride.gov.ar

news
For all inclusions under GACM please contact:

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http://www.gacm.de

1st GACM Colloquium for Young Scientists a Success

The Department of Civil Engineering at Ruhr-Universität Bochum has hosted the 1st GACM Colloquium for Young Scientists on Computational Mechanics, held from October 5-7, 2005. The meeting has been chaired by Klaus Hackl, Günther Meschke and Stefanie Reese, supported by their Organizing Committee Ulrich Hoppe, Detlef Kuhl and Olaf Schilling. It provided a platform for 110 PhD Students and Post-Docs from Germany and other countries to present and discuss their scientific achievements.

Figure1:
Günther Meschke, Ekkehard Ramm and Eugenio Oñate at the Reception

Figure 2:
Visiting the German Mining Museum

“From young people for young people” the colloquium was designed to foster scientific discourse particularly between the young members of our community. Not only did contributions from PhD students (and some Post-Docs) dominate the presentations, it were also mainly young members and students from Ruhr-Universität Bochum who organized the meeting and thus gave the event this very communicative and casual touch. For everybody involved in the organization the event started already more than one year before the official opening by the President of GACM, Ekkehard Ramm. They did a marvellous job and we are grateful for their great commitment.

The discussion of advanced computational methods and models for numerical analysis of materials and structures as well as the assessment of their suitability and robustness were in the main focus of the colloquium. Student presentations in two parallel sessions have been supplemented by plenary lectures provided by Karl Roll (from DaimlerChrysler), Eugenio Oñate and Ekkehard Ramm.

The great response to the announcement of this first event as well as its high scientific quality have already lead to concrete plans for a follow-up conference. It will be held in Munich in 2007, hosted by the Technische Universität München. ●

Figure 3:
Conference Participants in front of the Department of Civil Engineering

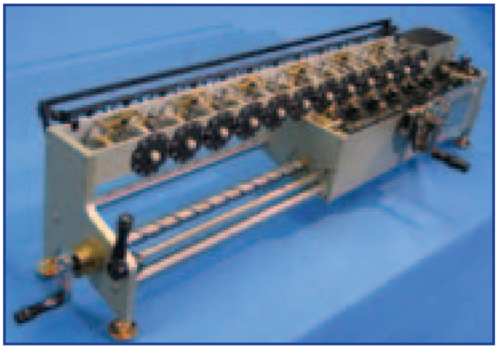
Professor Erwin Stein
awarded “von-Kaven-Förderpreis”

On 14 October 2005, Professor Erwin Stein (honorary president of GACM), Institute of Mechanics and Computational Mechanics, University of Hannover, was awarded with the first “von-Kaven-Förderpreis” by the Executive Board of the German Science Foundation (DFG), nominated by the representatives of German mathematicians. The ceremony took place at the Arithmeum, University of Bonn, with a following lecture by Professor Stein about new research results on Leibniz’ calculating machines and the construction of new functional models with improvements based on mathematical optimization.

The award was given to Professor Stein for his important scientific and engineering achievements in research and reproduction of Leibniz’ calculating machines, as well as outstanding achievements in Computational Mechanics. The new Hannover functional models of Leibniz’ decimal Four Function Calculating Machine and the binary “Machina Arithmeticae Dyadicae” recently were presented in Bonn, Linz, Vienna and Hannover, and will be part of a big Leibniz exhibition in the Orangerie of the Herrenhäuser Gärten in Hannover from 19 May to 11 June 2006 on the occasion of the 175th anniversary of the University of Hannover. ●

Figure 1:
Professor Erwin Stein during the award ceremony in Bonn on 14 October 2005

Figure 2:
New Hannover functional model of Leibniz’ Four Function Calculating Machine, scale 2:1



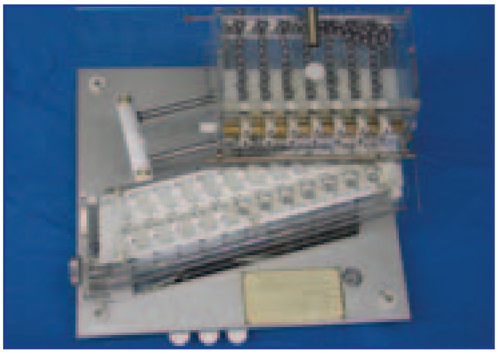


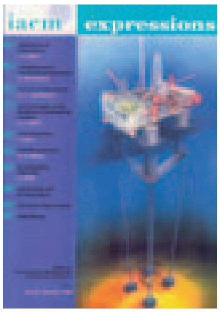
Figure 3:
New Hannover functional model of Leibniz’ description of a binary calculating machine

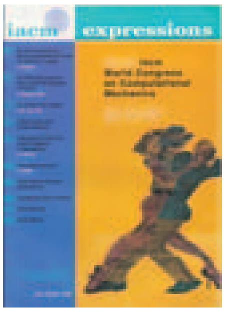
NUFRIC Course
held at the University of Hannover

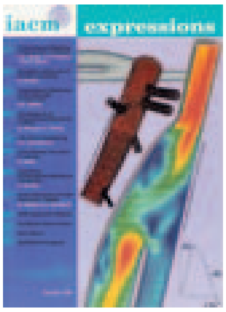
In **February 2006** a course on Computational Contact Mechanics was held at the University of Hannover by Profs U. Nackenhorst and P. Wriggers from the University of Hannover and by Prof. G. Zavarise from the Polytechnico of Torino, Italy. The course took place in a series of courses already held in Spain and Italy related to the Leonardo project NUFRIC which is funded by the EEC. This European project is aimed to disseminate knowledge regarding modern numerical simulation techniques applied to frictional contact problems at industrial level. It intends to develop material based on computer information technology, directed to technology and science that can significantly improve teaching and training in this specific application area.

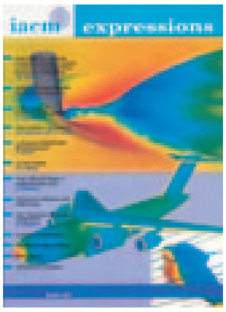
The partnership that presents the NUFRIC project consists of researchers from University of Granada, Spain, the UPC and CIMNE, Barcelona, Spain, the Polytechnico of Torino, Italy, and the University of Hannover, Germany. Furthermore the consortium TCN from Italy and the organisation NAFEMS from the U.K. are involved which present the needs from industry. ●

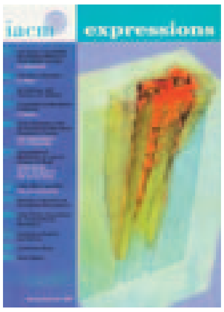
10 years of
IACM EXPRESSIONS
1996-2006

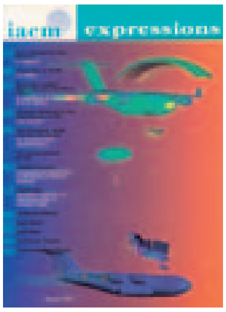


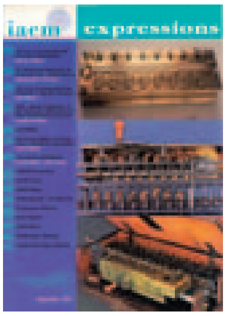


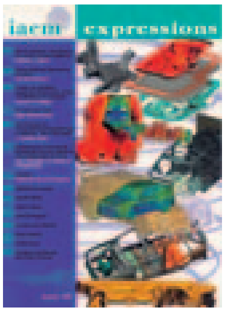


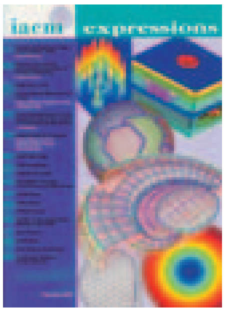


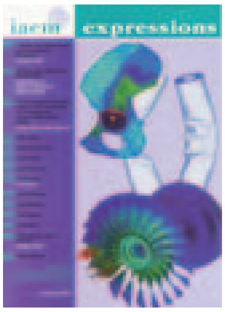


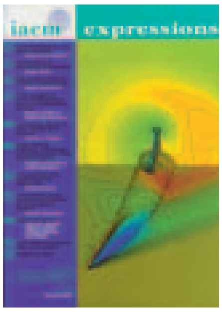


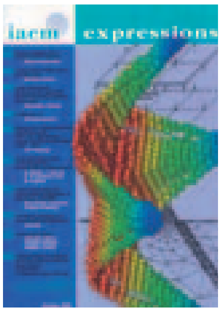


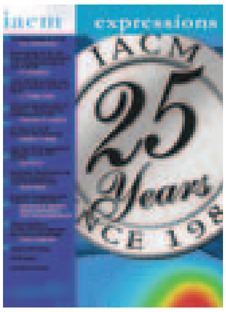












iacm news

Professor Genki Yagawa elected to Science Council of Japan

Professor Yagawa was elected to the Science Council of Japan, which was established in January 1949 as a special agency under the jurisdiction of the prime minister to promote science in government, industry and everyday life. It represents Japanese scientists at home and abroad with the philosophy that science is the foundation upon which a civilised nation is built.

New Executive Council has been elected for the AMCA

A New Executive Council has been elected for the Argentine Association for Computational Mechanics (AMCA), for the period 2005-2007. It is formed by: Victorio Sonzogni (president), Norberto Nigro (secretary), Mario Storti (treasurer), and as members of the executive council: Gustavo Buscaglia, Enzo Dari, Guillermo Etse, Carlos García Garino, Luis Godoy, Axel Larreteguy, Angel Menéndez, Marta Rosales and Marcelo Venere

New CEACM President

We would like to congratulate Jurica Soric of the University of Zagreb in Croatia on his election as the new Central-European Association for Computational Mechanics (CEACM) President.representing Austria, Croatia, Hungary, Poland, Slovenia, The Czech Republic and Slovakia.

New NoACM Director and Secretary

Our Congratulations are also forwarded to Anders Eriksson and Gunnar Tibert, both of KTH Mechanics, Sweden, who have been appointed the new Director and Secretary (respectively) of The Nordic Association for Computational Mechanics (NoACM) representing Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway and Sweden.

Book Report ~ Book Report

Advances in Smart Technologies in Structural Engineering

Jan Holnicki-Szulc and Carlos A. Mota Suares (Eds.)
211pp., ISBN: 3-540-22331-2, 2004
Edited by: Springer & ECCOMAS

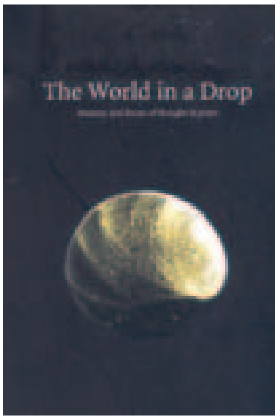
This book collects invited lectures presented at the AMAS ¬ ECCOMAS Workshop/Thematic Conference SMART'03 on Smart Material and Structures. The conference was held in Jadwisin, Poland near Warsaw, 2-5 September 2003. It was organized by the Advanced Material and Structures (AMAS) Centre of Excelence at the institute of Fundamental Technological Research (IFTR) in Warsaw and ECCOMAS - the European Community on Computational Methods in Applied Sciences and SMART-TECH Centre at IFTR. The goal of the workshop was to bring together and consolidate the community of Smart Materials and Structures in Europe. The workshop program was grouped into the topics Structural Control, Vibration Control and Dynamics, Damage Identification, and Smart Material. ●

The World in a Drop

Memory and forms of thought in water

Bernard Kröplin (Ed)
87pp., ISBN84-95999-82-X, 2005
CIMNE, Barcelona, Spain

Man and Water
Mind and Matter
Our world view distinguishes between natural science and humanities, between the world of the measurable and the world of unprovable notions. But actually it is all acts, and not that the acts are measurable. Otherwise your first great love would not have been actually and your children´s trust only illusion. There would be no honour and no ethics. When we now see in the drops that they talk to one another, when information and mental energy seem to generate systematic change, then it is worthwhile to at lease look closer, because this could be the measurable beginning of that which we all know intuitively, that mind permeates matter and that thoughts manifest themselves in material structurings much more extensively than we now thins possible ●

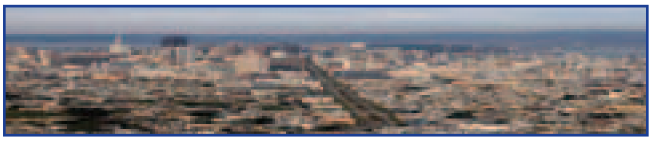


conference notices

9th US National Conference on Computational Mechanics

July 22-26, 2007
San Francisco, California, USA

Technical Program
July 22-26, 2007
Pre-& Post Short Courses
July 21-27, 2007
Hosted by:
University of California, Berkeley -
P. Papadopoulos, T. I. Zohdihonorary
(Honorary Chairmen),
Prof. Robert L. Taylor.
(Honorary Co-Chairman)
http://me.berkeley.edu/compmat/USACM/main.html ●



ICCMS - 06

2nd International Congress on Computational Mechanics & Simulation

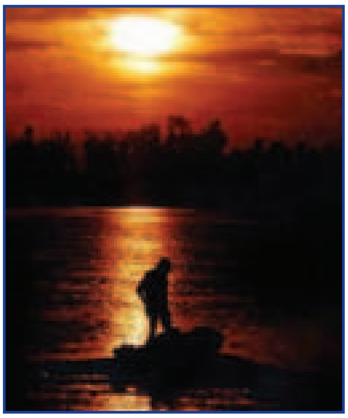
Indian Association for Computational Mechanics (IndACM) in collaboration with Indian Institute of Technology Guwahati announces International Congress on Computational Mechanics and Simulation **(ICCMS- 06)** to be held in **IIT Guwahati between 8-10 December 2006**. IndACM was founded on 1 January 2000 to bring together this community to have meaningful interaction to further the growth of computational mechanics in different disciplines. To achieve this objective ICCMS-04 was to provide a forum for scientists, engineers and designers in universities, laboratories and industry to share their research findings to further the cause of computational mechanics. We would like to invite you to submit your abstracts and register online at: **http://www.iitg.ac.in/iccms06/** ●

ENIEF'2006

XV Congress on Numerical Methods and their Applications

AMCA, the Argentinian Association for Computational Mechanics announces the **ENIEF 2006**: XV Congress on Numerical Methods and their Applications, to be held at **Santa Fe, Argentina**, on **November 7-10, 2006**. The local organization was given to the International Center for Computational Methods in Engineering (CIMEC), belonging to INTEC, which is an institute of the National University of Litoral (UNL) and the National Council for Scientific and Technological Research (CONICET), of Argentina.

One page abstract: April 15, 2006.
Full papers : July 15, 2006.
Web: **http://www. cimec.org.ar/ enief2006**
E-Mail: cimec@ceride.gov.ar ●



Figures 1 & 2:
Contrasting views of the Paraná River - Sante Fe

EASEC - 10

Tenth East Asia-Pacific Conference on Structural Engineering and Construction

The **Tenth East Asia-Pacific Conference on Structural Engineering and Construction (EASEC-10)** is to be held at the InterContinental Hotel, Bangkok, **Thailand**, **3-5 August 2006**

EASEC was founded by Professor Fumio Nishino, then the Vice President for Academic Affairs of the Bangkok-based Asian Institute of Technology. The objective of the Conference was to provide a forum for professional structural and construction engineers and researchers working in Asia and the Pacific region to present recent progress in research and development, and to discuss the implementation of new tools and technology in professional applications. In particular, the conference intends to promote mutual understanding and share common ideas.
Further information **www.easec10.net** ●

Thematic Conferences 2007

ECCOMAS organizes in Europe Thematic Conferences and Workshops in cooperation with universities, research centers and industry. In 2005 ECCOMAS organized 15 Thematic Events (see www.eccomas.org for details). A total of 22 ECCOMAS Thematic Conferences are planned for 2007. An announcement of each event is given below. For more information visit the ECCOMAS web page.

www.eccomas.org

1. KOMPLASTECH Computer Methods in Materials Science
Zakopane, Poland
14-17 January, 2007

2. Modelling Permeable Rocks V
Edinburgh University, UK
26-29 March 2007

3. ESAFORM 2007 Workshop on Advance Computational Methods in Material Forming
Zaragoza, Spain,18-20 April 2007

4. COUPLED PROBLEMS 2007 Computational Methods for Coupled Problems in Science and Engineering
Ibiza, Spain, 21 - 23 May 2007
http://congress.cimne.upc.es/coupled07

5. EUROGEN 2007 Evolutionary Methods for Design, Optimisation and Control with Applications to Industrial Problems
University of Jyväskylä, Finland, June 2007

6. Mechanical Response of Composites
Porto, Portugal, 4 - 6 June, 2007

7. Mathematical Modelling in Sport
The Lowry Centre, Salford Quays, Manchester, UK
24-26 June 2007

8. Multi-Scale Modelling in Material Science,
Hannover, Germany,
date to be confirm

9. MARINE 2007 Computational Methods in Marine Engineering
Barcelona, Spain, 4 - 6 June 2007
http://congress.cimne.upc.es/marine07

10. Composites with Micro- and Nano-Structure (CMNS) - Computational Modeling and Experiments
Liptovsk” Mikuláπ, Slovakia, 28-31 May 2007

11. International Conference on Computational Fracture and Failure of Materials
Nantes, France
11 - 13 June 2007

12. First International Conference on Computational Methods in Structural Dynamics and Earthquake Engineering Rethymno,
Crete, Greece, 13 - 15 June 2007

13. Modelling of Heterogeneous Materials with Applications in Construction and Biomedical Engineering
Prague, Czech Republic
25 - 27 June 2007

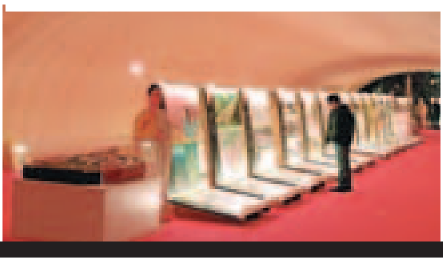
14. III International Conference on Advances in Computational Multibody Dynamics
Milano, Italy
25 - 28 June 2007

15. Computational Methods in Tunnelling - EURO-TUN 2007
Vienna, Austria, 9 - 11 July 2007

16. III Conference on Smart Structures and Materials
Gdansk, Poland,
9 - 11 July 2007

17. II Int. Conference on Computational Combustion
Delft University of Technology, Netherlands, 18 - 20 July 2007

18. STRUCTURAL MEMBRANES 2007- III International Conference on Textile Composites and Inflatable Structures
Barcelona, Spain, 17-19 September
http://congress.cimne.upc.es/membranes07



19. 9th. International Conference on Computational Plasticity - Fundamentals and Applications - COMPLAS 2007
Barcelona, Spain, 5 –7 September 2007
http://congress.cimne.upc.es/complas07

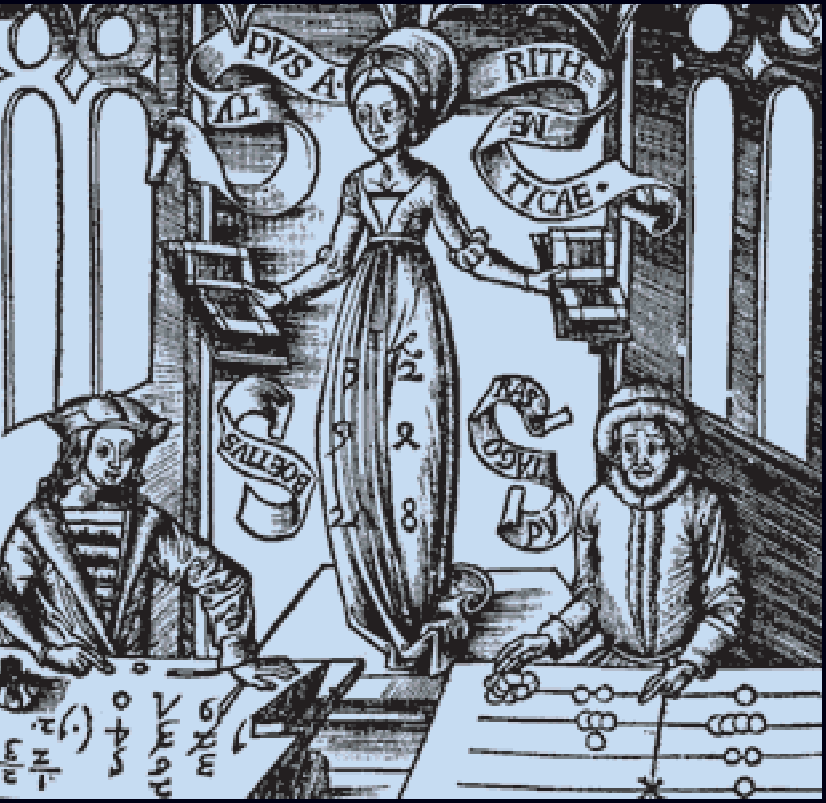
20. ADMOS III International Conference on Adaptive Modelling Simulation
Göteborg, Sweden
26 - 28 September 2007

21. I Computational Vision and Medical Image Processing
Porto, Portugal,
17 - 19 October 2007

22. III Conference Ai-Meth 2007 on Methods of Artificial Intelligence
Gliwice, Poland,
7 - 9 November 2007

conference diary planner

4 - 8 June 2006	**CSSM 2006 - III European Congress on Computational Solid & Structural Mechanics ECCOMAS 2006** *Venue: Lisbon, Portugal Contact: www.dem.ist.utl.pt/~cssm2006* *email: carlosmotasoares@dem.ist.utl.pt*
28 - 30 June 2006	**SEECCM-06 - First South-East European Conference on Computational Mechanics** *Venue: Kragujevac, Serbia Contact: www.seeccm06.kg.ac.yu* *email: nfilipov@hsph.harvard, brckg@kg.ac.yu*
2 - 6 July 2006	**ICSV13 - 13th International Congress on Sound and Vibration** *Venue: Vienna, Austria Contact: http://icsv13.tuwien.ac.at*
10 - 12 July 2006	**IABEM 2006 - International Association for Boundary Element Methods** *Venue: Graz University of Technology, Austria* *Contact: www.iabem2006.tugraz.at*
16 - 22 July 2006	**WCCM7 - VII World Congress on Computational Mechanics** *Venue: California, USA* Contact: www.wccm2006.northwestern.edu *Email: WCCM7@mail.mech.northwestern.edu.*
3 - 5 August 2006	**EASEC 10 - 10th East Asia-Pacific Conference on Structural Engineering & Construction** *Venue: Bangkok Contact: www.easec10.net*
5 - 8 September 2006	**Computational Fluids Dynamics - ECCOMAS CFD 2006** *Venue: Egmond aan Zee, The Netherlands* *Contact: www.eccomas.org*
12 - 15 September 2006	**5th International Conference on Engineering Computational Technology** **8th International Conference on Computational Structures Technology** *Venue: Las Palmas de Canaria Contact: www.civil-comp.com/conf/España*
8 - 10 December 2006	**ICCMS'06 - 2nd International Congress on Computational Mechanics and Simulation** *Venue: IIT Guwahati, India Contact: http://www.iitg.ac.in/iccms06/*
21 - 23 May 2007	**Coupled Problems 2007 - Conference on Computational Methods for Coupled Problems in Science and Engineering** *Venue: Ibiza, Spain Contact: http://congress.cimne.upc.es/coupled07*
4 - 6 June 2007	**Marine 2007 - Conference on Computational Methods in Marine Engineering** *Venue: Ibiza, Spain Contact: http://congress.cimne.upc.es/marine07*
5 - 7 September 2007	**COMPLAS 2007 - 9th International Conference on Computational Plasticity. Fundamentals and Applicatons** *Venue: Barcelona, Spain Contact: www.cimne.com*
17 - 19 September 2007	**Structural Membranes 2007 - III International Conference on Textile Composites and Inflatable Structures** *Venue: Barcelona, Spain Contact: http://congress.cimne.upc.es/membranes07*
26 - 28 September 2007	**ADMOS III - International Conference on Adaptive Modeling and Simulation** *Venue: Göteborg, Sweden Contact: admos07@cimne.upc.edu*
7 - 10 November 2007	**ENIEF'2006 - XV Congress on Numerical Methods and their Applications** *Venue: Sante Fe, Argentina Contact: http://cimne.org.ar/enief2006*
3 - 6 December 2007	**APCOM'07 Asian-Pacific Association for Computational Mechanics together with EPMESC XI -The Conference Board for the Enhancement and Promotion of Computational Methods in Engineering and Science** *Venue: Kyoto, Japan Contact: www.apacm.org/apcom07-epmescXI*
22-26 July 2007	**9th US National Conference on Computational Mechanics** *Venue: San Francisco, USA* *Contact: http://me.berkeley.edu/compmat/USACM/main.html*
30 June - 5 July 2008	**WCCM8 / ECCOMAS Congress 2008** *Venue: Lido Island, Venezia, Italy Contact: www.iacm.info / www.eccomas.org*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