

ACTE D'INVESTIDURA COM A  
DOCTOR *honoris causa*

DE LA

UNIVERSITAT POLITÈCNICA DE CATALUNYA · BARCELONATECH

DAVID ROGER JONES OWEN



ACTE D'INVESTIDURA DEL  
PROFESSOR DAVID ROGER JONES OWEN  
COM A DOCTOR *honoris causa*  
DE LA UNIVERSITAT POLITÈCNICA  
DE CATALUNYA · BARCELONA TECH

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# ORDRE DE L'ACTE D'INVESTIDURA

*Canticorum iubilo*, de l'oratori de *Judas Maccabaeus*  
(Georg Friedrich Händel).

Benvinguda del rector magnífic de la **Universitat Politècnica  
de Catalunya** · BarcelonaTech.

Lectura de l'acord del Consell de Govern, per part de  
la secretària general.

*La calma del mar*, de Nicolau Guanyabés (harmonització  
d'Enric Ribó).

*Laudatio* del padrí, el professor Eugenio Oñate.

Acte solemne d'investidura del professor D.R.J. Owen  
com a doctor *honoris causa* per la **Universitat Politècnica  
de Catalunya** · BarcelonaTech.

Discurs del nou doctor, el professor D.R.J. Owen.

*El rossinyol* (harmonització d'Antoni Pérez Moya).

Paraules del rector.

*Gaudeamus Igitur* (himne universitari, harmonització  
de Cornel Arany).

**Interpretacions musicals** a càrrec de la Coral Arquitectura i l'Orquestra de la  
UPC, sota la direcció de Lluís Carné i Miguélez.

# ORDER OF INVESTITURE ACT

*Canticorum iubilo*, from the *Judas Maccabaeus* oratorio by Georg Friedrich Händel).

Welcome from the rector of the **Universitat Politècnica de Catalunya · BarcelonaTech**.

Reading of the Governing Council's agreement by the general secretary.

*La calma del mar*, by Nicolau Guanyabés (arranged by Enric Ribó).

Oration by the sponsor, Professor Eugenio Oñate.

Conferral of the honorary doctorate on Professor D.R.J. Owen by the **Universitat Politècnica de Catalunya · BarcelonaTech**.

Honorary Degree Speech by Professor D.R.J. Owen.

*El rossinyol* (arranged by Antoni Pérez Moya).

Rector's speech.

*Gaudeamus Igitur* (universitary anthem, arranged by Cornel Arany).

**The music** will be performed by the School of Architecture Choir and the UPC Orchestra and conducted by Lluís Carné i Miguélez.

# ORATION FOR PROFESSOR DAVID ROGER JONES OWEN

by Professor Eugenio Oñate  
*Universitat Politècnica de Catalunya · BarcelonaTech*

Professor Roger Owen (Roger to his many friends) was born in Bynea (near Llanelli) in Wales, on 27th May 1942. He is Professor of Civil Engineering at Swansea University, Wales, UK, an international authority on finite element and discrete element techniques and the author of six textbooks and over four hundred scientific publications. In addition to being the editor of thirty monographs and conference proceedings, Professor Owen is also the editor of the International Journal of Industrial Engineering Computations and is a member of several editorial boards. His involvement in academic research has led to the supervision of seventy PhD students.

Professor Owen's research in the field of solid and structural mechanics has centred on the development of solution procedures for non-linear problems encountered in science and engineering. After undertaking his initial degrees at Swansea University, he completed his PhD at Northwestern University, in the USA, under the guidance of Professor T. Mura, in the field of theoretical and applied mechanics. This work, and also



his early post-doctoral experience as Walter P. Murphy Research Fellow at Northwestern, involved both the analytical and computational study of fundamental plastic material deformation described by continuously distributed dislocation mechanisms. Professor Owen subsequently returned to Swansea University to take up an academic post in the Department of Civil Engineering, where, under the influence of Professor O. C. Zienkiewicz, he developed an interest in computational methods. From that time, Professor Owen has contributed prominently to the development of computational strategies for plastic deformation problems, both for fundamental material studies and for application to engineering structures and components.

Over the last two decades, Professor Owen's work has focused on the development of discrete element methods for particulate modelling and the simulation of multi-fracturing phenomena in materials, where much of his research has been pioneering. This work has extended developments in the continuum modelling of finitely deforming solids by including damage- and



fracture-based failure and introducing material separation on a local basis to permit simulation of the degradation of a continuum into a multi-fractured particulate state. Contributions based on this methodology have been made to fundamental understanding in several key application areas, including explosive simulations that necessitate coupling of multi-fracturing solid behaviour with evolving detonation gas distribution, deep-level mining/oil recovery operations, defence problems related to high velocity impact involving penetration of metal and ceramic materials and structural failure predictions for impact, seismic and blast loading.

With an interest in solving large-scale problems, Professor Owen has, over the last three decades, been engaged in the development of parallel processing strategies for the simulation of engineering and scientific problems. Commencing from early work on shared memory machines, his most recent work has involved implementation on distributed memory platforms, where, for problems involving multi-fracturing solids or adaptive mesh refinement in which continual changes in mesh topology take place, the development of dynamic domain partitioning schemes and incremental inter-processor data migration is essential.

More recently, Professor Owen has become involved in research for describing random media fields in stochastic finite element modelling with a view to modelling both uncertainties in the distribution of material properties and the presence of internal fractures in geomechanical and other solids. A further topic of research has been the coupling of particulate systems and multi-fracturing solids with other physical fields, involving liquids or gases, through the introduction of a lattice Boltzmann description.

Professor Owen plays a leading role in national and international scientific affairs. For example, he is a member of the Executive Council of the International Association for Computational Mechanics (IACM), a worldwide organisation established to promote and guide research and applications in the field of numerical

modelling. It is pertinent to point out that the office of the general secretary of the IACM is located at the UPC's International Centre for Numerical Methods in Engineering (CIMNE). He is a board member of the European Council for Computational Mechanics (ECCM) of the European Community on Computational Methods in Applied Sciences (ECCOMAS, whose general secretary's office is also located at the CIMNE) and was, in the past, also the chairman of the UK Association for Computational Mechanics in Engineering, which is the national association affiliated to the IACM. A further measure of Professor Owen's research esteem is his membership of the Research Assessment Exercise panel for Civil Engineering in the UK in 2001. He has been appointed to similar panels for the corresponding exercise in mechanical engineering in the Netherlands (QANU, Quality Assurance Netherlands Universities) in 2000 and 2008, and the Deutsche Forschungsgemeinschaft (DFG) in Germany, in 2006 and 2007, for its graduate schools, centres of excellence and institutional funding initiatives. He was also a member of the International Advisory Board for the Institute for High Performance Computing in Sin-



gapore for five years. Due to his industrial involvement, Professor Owen served for over ten years as elected council member of NAFEMS, an international organisation aimed at establishing standards and quality assurance procedures for the safe use of finite element methods. Professor Owen has recently been elected a member of the Civil Engineering Panel for the UK Research Excellence Framework (REF) exercise to be undertaken in 2014.

Professor Owen's contribution to research has been recognised in the form of the following awards and distinctions:

- He was elected a fellow of the Royal Academy of Engineering in 1996.
- He was awarded an honorary DSc by the University of Porto, Portugal in 1998.
- He received the Computational Mechanics Award of the International Association for Computational Mechanics (IACM) in 2002 for "outstanding contributions in the field of computational mechanics".
- He was awarded the Warner T. Koiter Medal of the American Society of Mechanical Engineers (ASME) in 2003 for "contributions to the field of theoretical and computational solid mechanics".
- He was awarded the Gauss-Newton Medal by the IACM in 2004 for "outstanding contributions in the field of computational mechanics".
- He was awarded the Gold Medal of the University of Split, Croatia in 2004 for "international achievements in the field of computational mechanics".
- He was awarded the Premium Medal of the Spanish Society for Computational Mechanics (SEMNI) in 2005 "in recognition of his outstanding scientific work". The SEMNI was created in 1989 on the initiative of a group of academics at the UPC, and its general secretary's office is located at the UPC's CIMNE.
- He was awarded an honorary DSc by the Ecole Normale Supérieure de Cachan, France in 2007.
- He was elected a fellow of the Royal Society in 2009. This is one of his greatest scientific achievements.
- He was appointed honorary professor at the Welsh Institute for Mathematics and Computational Science in 2009.



- He was a founding fellow of the Learned Society of Wales in 2009.
- He received the Outstanding Research Activity Award from Swansea University in 2009.
- He was awarded the Grand Prize of the Japan Society for Computational Engineering and Science (JSCES) in 2010.
- He was elected foreign member of the United States National Academy of Engineering (NAE) in 2011.

## NAMED LECTURES

Professor Owen is a very fine lecturer. As a former student of his and fellow lecturer in many joint courses, I can say that his lectures are most enjoyable and highly appreciated by students. He has been invited to deliver the following named lectures:

- 2002 Prestige Lecture of the Institution of Civil Engineers and the Royal Academy of Engineering, Institution of Civil Engineers, November 2002.
- 2003 Warner T. Koiter Lecture of the American Society of Mechanical Engineers, Washington DC, November 2003.
- 2007 Alan Jennings Memorial Lecture, Queen's University Belfast, April 2007.
- 2011 Higginson Lecture, Durham University, November 2011.

In addition, he has presented a total of over 90 keynote and plenary lectures at leading international conferences in the field of computational mechanics.

## ENTREPRENEURSHIP

In 1985, Professor Owen formed Rockfield Software Ltd., which aimed to disseminate his academic research on computational modelling procedures to the industrial sector. The company initially employed two engineers and was based in the Innovation Centre at Swansea University. Over subsequent years, Rockfield Software has expanded to over 35 employees; over two thirds of these employ-

ees hold PhD degrees, making the company a leading employer of high-calibre technology graduates in the Swansea area.

The success of the company led to relocation firstly to Technium I in the SA1 Development in Swansea, followed by a permanent move to the Ethos Building, also in SA1, which it was instrumental in designing and building together with Rowland Jones & Partners.

Rockfield has a wide portfolio of clients and operates in several commercial areas. Principal sectors in which the company is involved include:

- Failure prediction for structures under seismic or blast loading.
- Industrial forming processes for glass, plastics and metals.
- Food technology processes.
- Defence applications involving explosive and impact conditions.
- Deep level mining and other mineral recovery operations.
- Oil recovery operations and resource prediction.

In addition to both UK and overseas SMEs, Rockfield has over the years built strong relationships with many of the world's leading companies, including Unilever, DSTL, Qinetiq, Corus, Proctor & Gamble, Devonport Marine Ltd., Rio Tinto, BP-Amaco, Shell, Exxon Mobil, Total-Fina-Elf, Miningtek, Orica, Anhauser Busch and the Los Alamos, Sandia and Lawrence Livermore National Laboratories. The prominent involvement of Rockfield in the mining and mineral recovery sector led to the formation of Rockfield Technologies Australia, which is based in Townsville, Queensland, to support these activities. The company currently employs eight R&D engineers.

The success of the company has led, under Professor Owen's chairmanship, to the granting of the Queen's Award for Innovation on two separate occasions:

- In 2002, Rockfield received the award for the development of finite element/discrete element simulation techniques for the

strengthening of masonry bridges and arches. This technology has been used, within a consortium that includes Cintec International and Gifford & Partners, to provide services that include assessing the need for strengthening; determining the precise location for insertion of retrofitted reinforcement anchors using the FE/DE approach; and installing anchors cleanly and efficiently.

- In 2007, the award was granted for outstanding innovation in the development of the ELFEN computational system for the simulation of multi-fracturing solids. Recognition was given to the versatility and widespread industrial application of the methodology in diverse areas such as blast and impact loading of structures, defence applications, mining and minerals operations and oil recovery processes.

Since he founded Rockfield Software, in 1985, Professor Owen has been its managing director and then its chairman until his retirement from the company in 2010.

## RELATIONSHIP WITH THE UPC

Professor Owen has a long-standing relationship with the UPC. As early as December 1979, he and Professor Ernie Hinton organised the first basic course on the finite element method, which was attended by some 70 participants from all over Spain. Indeed, the course, which was held every December for 10 consecutive years up to 1989, can be considered to be the foundation of the numerical methods community at the UPC's Barcelona School of Civil Engineering. Roger and Ernie's visits to the UPC around 15th December every year soon became a tradition, almost a pre-Christmas event, that brought us many good moments of scientific exchange and friendship with our colleagues from Swansea. Soon enough, a series of very successful international conferences –first in the field of non-linear finite element methods (1984) and then in computational plasticity, the so-called COMPLAS conference series that has run for 11 editions at the UPC since 1986– were added to the course. COMPLAS

will again take place in Barcelona, in this very auditorium, in September 2013.

Sadly, Ernie Hinton, with whom Roger had published a number of seminal books on the finite element method, died in November 1999. Cooperation with Roger and his team continued, however, through the COMPLAS conference series, and even led to the creation, in conjunction with the UPC, of international conferences in new fields, such as the International Conference on Computer Aided Training in Science and Technology, held in Barcelona in 1990, and a series of conferences in the field of particle methods. The two first editions of the Particle Conference took place in Barcelona in 2009 and 2011, and the third will be held in Stuttgart in October 2013.

I would like to emphasise that the COMPLAS conference series has established itself as an international reference in the field of computational solid mechanics. Over 3000 colleagues and friends have attended one of the editions of this conference, which combines scientific excellence with an informal setting and a select social programme.

I would also like to mention the significant support given by Professor Owen to the activities of the International Centre for Numerical Methods in Engineering (CIMNE). Indeed, the CIMNE, which this year celebrates its 25th anniversary, was created in 1987 to provide support for the many activities in the field of numerical methods taking place at the UPC, and in particular at the Barcelona School of Civil Engineering. It is important to note that, in 1987, the UPC's collaboration with Professor Owen and Swansea University had already been intensive for nine years. The UPC's interactions with Professor Owen and his team at Swansea over the last 25 years are indeed too many to name, but I can say that they were strengthened by the fact that Professor Zienkiewicz, one of the founders of our computational mechanics community and the former director of the Civil Engineering Department at Swansea, stayed at the UPC regularly



over a period of 20 years due to his role as UNESCO Professor of Numerical Methods in Engineering. The UNESCO Chair of Numerical Methods in Engineering was the first UNESCO chair to be set up on the initiative of the UPC, in 1989.

Many European research projects, joint courses, workshops, seminars and scientific meetings have taken place in cooperation with Professor Owen and his team over that period. All of them have helped the UPC to establish a reputation in the field of numerical methods in engineering and computational mechanics. Roger, many thanks for that. I'd be surprised if you hadn't visited the UPC and Barcelona over a hundred times.

I must also mention the significant role that Roger has had in supporting the Spanish Association for Numerical Methods in Engineering (SEMNI). This scientific organisation, created in 1989, gave Roger its highest award in recognition of his scientific merits and also for his contribution to the development of the field in Spain. The SEMNI will celebrate its 25th anniversary in 2014. In honour of that fact, it is organising, in cooperation with the CIMNE and the Barcelona School of Civil Engineering, three major events in Barcelona, which will take place simultaneously: the World Congress on Computational Mechanics, the European Conference on Solid and Structural Mechanics and the European Conference on Fluid Dynamics, all of which promise

to be landmark events in the field of computational methods in engineering and applied sciences.

Roger has also been very supportive of the Latin American community devoted to numerical methods in engineering. He was a founding member of the Mexican association in that field and as such took part in the inaugural conference in Guanajuato in January 2002. He has also participated in scientific events on computational mechanics in Argentina, Brazil and other Latin American countries.

In more personal terms, I consider Roger to be a friendly, cheerful person. He is one of those people who find it difficult to say no to a request from a colleague or friend. He is extremely hard-



working and, among his hobbies, I can say that he is a fine airplane pilot, an activity that took up quite a bit of his time some years back; a supporter of the Welsh rugby team; and an expert on international cuisine and good wines. He also has a reputation for his COMPLAS after-dinner stories, which deserve to be collected in a separate volume of this conference series.

Finally, I would like to express my gratitude to the UPC's Department of Strength of Materials and Structural Analysis for proposing Roger for this honorary doctorate award, and to the many institutions and individuals who have supported the proposal. Many thanks to all of you for participating in this memorable event and in particular to the many colleagues and friends who have travelled from other parts of Spain and from countries around the world to be here today. We are very proud to have distinguished representatives of national and international organisations and academies in Spain, other European countries, the USA, Japan, Korea and several Latin American countries. Many thanks to all of you for lending your support to this event.

Dear Roger, time has flown since you first landed at the UPC in December 1979. The work of many people, including yours, has not been in vain, and the modern UPC of today has little to do with what it was 32 years ago. At the UPC, we all recognise that your contribution has been very important in transforming the UPC into a world reference in the field of computational engineering.

Many thanks for all of that and, above all, many thanks for your friendship.

Thank you very much.

# HONORARY DEGREE SPEECH BY PROFESSOR D.R.J. OWEN

## FROM BYNEA TO BARCELONA A CELTIC/CATALAN ODYSSEY

D. Roger J. Owen, Swansea University, UK

### INTRODUCTION

The connection between Swansea University and the Universitat Politècnica de Catalunya (UPC), Barcelona extends over 35 years, commencing with the arrival at Swansea of Eugenio Onate in 1976 to undertake PhD studies under the direction of Prof. O.C. (Olek) Zienkiewicz. This relationship continues to the present time –indeed the current Head of the Engineering College at Swansea, Javier Bonet, is a UPC graduate. Over this period, a continuous collaboration has taken place between the two institutions in research, workshop, course and conference organisation, international projects and other activities. Apart from myself, other people from Swansea have been engaged over the years in joint ventures with the UPC, but for the purpose of this presentation I will confine discussion to my specific activities.



This presentation is divided into several sections, each dealing with some aspect of my career and, hopefully, they will provide some insight into my long-term association with the UPC.

### THE EARLY YEARS

I was born on 27 May 1942 in the village of Bynea, near Llanelli at the house shown in Figure 1. My parents were Evan William and Margaret Owen and I have one sister, Rita, four years my senior, who entered the teaching profession and ended her career as Headmistress of a primary school in the Llanelli district. My antecedents on my mother's side came from West Wales, with my great-grandmother being the daughter of the Squire of Rhydlewis. She eloped with my great-grandfather who was a groom to the Squire and, unfortunately, was disinherited for this social misdemeanour. On my father's side, the family split in two when several members emigrated to Pennsylvania, USA in 1895 to seek work in the steel industry. On reaching Ellis Island in New York the immigration officer wishing to confirm the family name - asked "Owens?" Not understanding fully my

great-great uncle answered “Yes” and to this day the American branch of the family has an extra “s” to its name. Back in Wales, my paternal grandfather ran a market garden business named Bynea Nurseries. My father was mathematically gifted, but was denied an extended education, leaving school at twelve in order to work in the family concern. In addition to this occupation, he later became a roller-man at the local steel works.

My mother, as was the norm, looked after the family home, as well as supporting the family business. My maternal grandmother, who could speak only Welsh, lived with us at the time. In fact, the family language was Welsh and even to this day when I am speaking with my sister and cousins the conversation inevitably reverts to Welsh within half a dozen sentences. The only member of our family who achieved professional status was my mother’s brother, Jack (John Rhagfyr Jones), who became a chartered architect and surveyor in 1937 (ARIBA, PASI) and unfortunately died in India during World War II as a captain in the Royal Engineers. The early years of my life were typical of the wartime and early post-war era and involved the strictures of food and other rationing. Bynea was a small, close-knit village whose population depended on the steel and tinplate industries around Llanelli.

## EDUCATION

My initial education took place at Bynea Primary School (Figure 2), where the headmaster was Major Isaac Thomas who, undoubtedly due to his military background, was a strict disciplinarian. He was a remarkable man who instilled in us many of the ground rules and virtues of life and was one of the first people to have a profound influence on my future. As well as having the judgement of Solomon, he was quite liberal with the use of a cane, which he carried under his arm as a swagger stick –also earning him the sobriquet “Isaac Bamboo”. When I was ten I was successful in the “Eleven Plus” examination and entered Llanelli Boys Grammar School in 1953.

In common with all grammar schools, the initial education it offered was broad, with a balance of arts and science subjects. In fact, I performed well in the arts subjects, achieving 95% in Latin during the first two years. This mark was quite an achievement in those days and pupils would stop me in the corridor to ask if this was correct. I interpreted their look to be one of awe, but I later realised it was probably pity. However, I decided to specialise in science and studied a curriculum leading to the O-Level examinations in 1958, followed by two years of sixth form study in Pure Mathematics, Applied Mathematics and Physics, culminating in the A-Level examinations. Many of the teachers I encountered at the school were wonderful characters who enriched my school days. There was a large degree of eccentricity to be found in many of them and I suspect that they would have found it difficult to exist in the present Health & Safety and Politically Correct environment governing schools –especially as many had military service records reaching back to World War II. Nevertheless, they provided me with a wonderfully varied education. Also, I was the first of my family to have the opportunity to go to university and that would have been impossible without the education I received at Llanelli Boys Grammar School and the scholarship system operating at that time, which allowed free access to universities.

On completing my secondary education I had the choice of either undertaking a Civil Engineering degree at Manchester University or a similar course at the University of Wales Swansea. For financial and personal (involving my future wife, Janet) reasons, I decided to study at Swansea. Studying at Swansea proved to be an inspired, and fortunate, choice as during my first year at Swansea the then head of department, Prof. Bernard Neal, left for Imperial College (and greater duties with the All England Croquet and Wimbledon Lawn Tennis Association) to be replaced by my mentor Prof. Olek Zienkiewicz. Olek was destined to become the leading figure in the field of finite elements, which was beginning to emerge as a revolutionary research area in the early 1960s.



I completed my first degree in Civil Engineering in 1963 followed by my master's, which I concluded in 1964. During this final year I expressed a wish to Olek to study abroad and he arranged for me to undertake PhD studies at Northwestern University at Evanston, a suburb of Chicago. Olek had been a Professor of Structural Engineering at Northwestern before taking up his position at Swansea. (I did have another offer from Caltech but this involved a considerable degree of teaching as a graduate instructor). It should be mentioned that at this point Janet and I had married and she accompanied me on this great (in 1964 at least) adventure. Janet worked in the Alumni Office of Northwestern and supplemented our comfortable existence for the next two and a half years. Upon completing my PhD in 1966, I spent a period as Walter P. Murphy Research Fellow at Northwestern before Olek persuaded me to take up a position as a research fellow at Swansea –to which I agreed on the basis that I would remain at Swansea for one year only!

## ACADEMIC CAREER

In the Department of Civil Engineering at Swansea I was rapidly introduced to the finite element method and was seduced by the exciting research prospects in the area and the enthusiastic and refreshing manner in which Olek ran the department. Administrative tasks were kept to an absolute minimum, teaching duties were efficiently dispatched and research was encouraged at every opportunity. Thanks to the creation of the world-renowned Institute for Numerical Methods in Engineering at Swansea, there was a continual exchange of research visitors and it was not unusual to find six to eight scholars, each of them an academic of substantial rank at his/her home institution, visiting the department at any given time. I subsequently spent the next forty years at Swansea.

It was at this time that our two daughters were born; Kathryn in 1967 and Lisa in 1970. Kathryn undertook a Business Studies



degree at Swansea University, subsequently chose an academic career and is currently a lecturer at the International College of Wales Swansea, which is based on the campus of Swansea University. After serving for ten years in the Royal Air Force, Lisa went to Cardiff University and trained as a radiographer and is employed at Singleton Hospital in Swansea. I have one granddaughter, Bethan, born to Lisa in 2002, who is showing signs of being mathematically talented.

I commenced my research career and formed an early link with Prof. Ernie Hinton, who unfortunately died of cancer in his early fifties. In addition to collaborating on scientific papers, we embarked in 1977 on writing a text book describing the practical



implementation and application of the finite element method. This text, entitled *Finite Element Programming* and published by Academic Press became a classic book. It is still in print and it has been mimicked by many authors. Also, the code and coding style became embedded in several commercial and research codes and the structure and variable names can be found in codes to the present day.

In writing this book we were asked, naturally, to produce the text, also to provide the line drawings and to proof read the manuscript. However, when we were asked to undertake marketing by providing a list of people who would like to purchase such a book we began to wonder how much value the publishers were providing. At around the same time Ernie and I were completing another book, *Finite Elements in Plasticity: Theory and Practice* and the idea of alternative ways of publishing became attractive. Therefore, together with a colleague, Cedric Taylor, I set up a publishing company, Pineridge Press, and set about producing this new book. We knew nothing about publishing and after selecting a possible printer by examining the frontispiece of several texts we chose a company named Redwood Burn and arranged to visit them in Trowbridge, Wiltshire. After displaying our ignorance of all things related to printing and publishing, we were asked how many copies we wished to print. We tentatively suggested 2,000 copies and asked if they could manage this. They replied that they could probably squeeze it in between the 500,000 copies of the Guinness Book of Records that they were currently working on. However, from this improbable start we forged a strong relationship with Redwood Burn and at the peak of the company's operation Pineridge Press had a portfolio of over 150 computational modelling-related texts. It should also be said that Pineridge was equally successful as the major publishers in the field of computational mechanics, with sales figures of individual titles matching those of these international organizations.

The importance of the finite element method to industrial analysis and design inevitably led to my involvement in commercial

exploitation of the methodology. In 1985, in keeping with other universities, Swansea developed an Innovation Centre with the explicit remit of exploiting academic research. I was approached by the then vice-chancellor, Prof. Brian Clarkson, to set up a commercial company within this centre. Beginning from a staff of two employed through work I was undertaking for a glass research organization, this company, Rockfield Software Ltd., has currently grown to 35 employees in the UK and 10 in Australia. The company is recognised as an internationally leading advanced engineering analysis solution provider to a wide range of industrial sectors. The company's clientele includes international and multinational organisations from the oil and gas sectors, the mining sector, the defence field, forming process industries and other companies.

Over the last decade Rockfield has twice been granted the Queen's Award for Innovation, the most prestigious industrial award in the UK. In 2002 they achieved this distinction through the development and application of world-leading finite/discrete element technology for the retrofit strengthening of masonry bridges and arches. In 2007 the award was given for the development of an innovative computational system for the simulation of multi-fracturing solids, with applications to the defence, mining and oil recovery sectors.

## RESEARCH CAREER

My research in the field of solid and structural mechanics has centred on the development of solution procedures for non-linear problems encountered in science and engineering. This work, which is predominantly computationally based, encompasses fundamental constitutive modelling, algorithmic developments and advances in numerical solution procedures, addressing a wide range of application areas.

I completed my PhD at Northwestern University, under the guidance of Prof. Toshio Mura, in the field of Theoretical and



Applied Mechanics. This work, and also my early post-doctoral experience as Walter P. Murphy Research Fellow at Northwestern, involved the analytical study of fundamental nonlinear material deformation. Exploiting the relationship between dislocation density and eigenstrain distributions, continuously distributed dislocation mechanisms were derived which reproduce macroscopic elasto-plastic material deformation; e.g. Ref. [1].

Following my return to Swansea, under the influence of Olek Zienkiewicz I developed an interest in computational methods. From that time, our group has contributed to the development of computational strategies for plastic deformation problems, both for fundamental material studies and for application to engineering structures and components. Our numerous research contributions to the field are internationally recognised and are best summarised in the extensively cited text on Computational Plasticity [3] –as well as the more modern version of this text [21].

Early work in this area involved the development of finite element methods for the solution of small-strain elasto-plastic



problems. Reference [2] and Figure 3 describe the development and application of the method to the case of a notched bar in bending and deserves mention because the numerical solution demonstrated that the hitherto considered “exact” analytical solution for a perfectly plastic Tresca material was, in fact, invalid due to a deficiency in the initial assumptions made. This is an early (but small) example of computational methods acting as “the third pillar of scientific progress”.

I continued to contribute to the development and application of nonlinear finite element methods from the seventies onwards; for example, References [3-6]. Specifically, the text [3] brings together the theoretical and computational aspects of elasto-plastic material deformation to provide comprehensive solution strategies for practical problems. Reference [4] introduces anisotropic effects into the computational modelling of elasto-plastic plates and shells and References [5,6] document two of many studies devoted to the analysis of laminated plates and shells.

My research in the late 1980s and 1990s moved on to the computational treatment of elasto-plastic problems involving finite strains. At this time, the implications of the necessity for consistent linearization of return mapping schemes had become apparent and the deformation kinematics for finitely straining solids became better understood. A key contribution to the field was the introduction of logarithmic strain as the fundamental measure, which, together with the concept of the exponential map for integration of the rate equations, established a sound computational basis for plastically deforming materials under finite strain conditions [7, 15]. Figure 4 illustrates the simulation of a food can under vacuum loading, comparing numerical prediction with experimental observation, while Figure 5 displays the penetration of a steel target obliquely impacted by a tungsten missile. All of this work relied extensively on the contributions of Prof. Djordje Peric, who originally came to Swansea as a PhD student but quickly blossomed as a researcher of international standing in his own right. Prof. Peric is now recognised as a leading figure in the field of computational mechanics. Another former student who has contributed prominently to computational mechanics research at Swansea is Prof. Eduardo de Souza Neto, whose work on the computational modelling of finitely deforming solids, damaging materials and multi-scale modelling is internationally recognised. Both are currently well-established researchers within the Civil & Computational Engineering Centre at Swansea.

Practical problems involving finitely deforming elasto-plastic solids almost invariably include frictional contact conditions. Such phenomena are highly nonlinear, making their computational simulation problematical and References [8, 12] introduce a consistent tangent model that has a local quadratic rate of convergence. With a view to modelling material failure, damage models have been incorporated within the finite-strain elasto-plastic framework. In this context an additive split of the principal stress space has been introduced to incorporate different rates of damage under tensile and compressive regimes [18]. Other contributions to nonlinear computational mechanics in-

clude the modelling of strain localisation phenomena in both classical and Cosserat continua [10].

A natural extension of finite strain modelling is the need for adaptive mesh refinement to accommodate the gross geometric deformations involved in such problems. Our group has contributed to strategies for nonlinear problems under both static and dynamic conditions. Publications [10, 13, 15] and references cited therein summarise contributions made to strategies for the mapping of a consistent set of variables between successive meshes for elasto-plastic conditions and discuss application to a range of practical static and dynamic problems.

With an interest in solving large-scale problems, I have over the last three decades been engaged in the development of appropriate computational methods for such simulations. Commencing from early work on shared memory machines, my most recent work on parallel processing strategies has involved implementation on distributed memory platforms, where for problems involving multi-fracturing solids or adaptive mesh refinement, in which continual changes in mesh topology takes place, the development of dynamic domain partitioning schemes and incremental inter-processor data migration is essential (e.g. [17] and references cited therein). Other contributions have involved the development of solution procedures for large-scale equation systems. In this context, conjugate gradient methods have been developed for non-symmetric equation systems, which, when embedded within a Galerkin multi-grid method, provide efficient solution of very large equation sets [14]. The non-nested nature of the multi-gridding allows the mesh generation and variable mapping algorithms employed in adaptive mesh refinement strategies to be directly exploited.

Following on from the study of damaging and fracturing materials, my work has focused over the last two decades on the development of discrete element methods for particulate modelling and the simulation of multi-fracturing phenomena in materials.

This work has extended developments in the continuum modelling of finitely deforming solids by including damage/fracture-based failure and introducing material separation on a local basis to permit simulation of the degradation of a continuum into a multi-fractured particulate state [11, 16, 17]. Key issues in this methodology include the modelling of incipient fracture on a continuum basis, procedures for the insertion of discrete fractures, the mapping of solution variables between the continuous and discontinuous states, energy and momentum preservation, and subsequent modelling of the combined continuum/discrete particle system developed. In the latter context, the establishment of global search procedures for the efficient detection of potential contact between particles is of crucial importance; for example, [17] and references therein. Based upon this methodology, contributions have been made to fundamental understanding in several key application areas, including explosive simulation, which necessitates coupling of the multi-fracturing solid behaviour with the evolving detonation gas distribution, defence problems related to high-velocity impact involving the penetration of metallic and ceramic materials, and structural failure predictions for impact, seismic and blast loading. Figure 6 illustrates the penetration of a reinforced concrete slab by a missile that is intended to represent a jet engine strike on a nuclear containment structure. Figure 7 shows the controlled fragmentation resulting from the designed sequential explosive blasting of a mining bench in an open cast coal mine. A key research collaborator in this area has been Prof. Y.T. Feng, who has contributed prominently to fundamental aspects such as contact search algorithms and, in particular, to the coupling of particulate systems and multi-fracturing solids with other physical fields, involving liquids or gases, through the introduction of a Lattice Boltzmann description [19].

More recently, I have become involved in research for describing random media fields in stochastic finite element modelling with a view to accounting for both uncertainties in the distribution of material properties and the presence of internal fractures in geo-mechanical and other solids [20]. Collaboration with Dr. Chenfeng Li has been the key driver of this work.

## SWANSEA-UPC CONNECTION

The Swansea-UPC connection began with the coming of Eugenio Onate to Swansea in 1976 (over 35 years ago!) to undertake a PhD degree with Olek Zienkiewicz, working in the area of metal forming. After receiving his PhD in 1978, he took up a position at Barcelona and over the next decade developed CIMNE (International Centre for Numerical Methods in Engineering), which is now internationally recognized as a leading research centre. It is also appropriate to mention that this year marks the 25th anniversary of CIMNE. This is a tribute to the foresight and vision essential for its creation, in addition to the excellence of its researchers over the years. In December 1979, Prof. Ernie Hinton and I were invited by Eugenio to teach a course on finite elements at Barcelona and these courses, which were traditionally taught just before Christmas, became regular events and covered a range of nonlinear topics. At about this time, we also decided to organize a conference on Nonlinear Computational Methods, which was subsequently followed by conferences on Coupled Problems and Computational Plasticity. The series of conferences related to the computational modelling of plasticity problems (COMPLAS) are now recognized as amongst the leading events in the field and the 12th conference will be held in Barcelona in 2013. The short course activities also run to the present day in the form of the short course attached to the COMPLAS conferences. The original conference on Coupled Problems is also thriving in the form of a series of events hosted on successive Mediterranean islands, with the next being held in 2013 in Ibiza to celebrate Eugenio's 60th birthday.

The first courses were taught at the former premises of the Civil Engineering Department, which were based in the grounds of an old convent. Indeed, one of our first conferences was held in the chapel situated in the grounds. This formed an idyllic setting for meetings and discussions; as well as *al fresco* coffee sessions and conference receptions. Later, of course, our activities moved to the new engineering campus (Campus Norte) of the UPC.

From the early 1980s onwards, my research activities –and indeed others at Swansea– have been closely linked with complementary work at Barcelona. The primary interests of most research groups during that period in the area of solid mechanics focused on the development of computational procedures for, first, quadratically convergent procedures for elasto-plastic problems, followed by the treatment of finite deformation conditions. This was an extremely exciting decade in computational modelling, with many innovative algorithms and approaches being generated. The result of these developments was that by the early 1990s industrial problems involving finitely deforming elasto-(visco)-plastic materials could be solved with a degree of confidence.

This consequently led to a close collaboration with Barcelona in numerous EU research projects, through Framework, Craft and other initiatives, centred on the simulation of industrial forming processes. Other European led projects included the development of computer-based tuition concepts and their promotion through distance learning paradigms, resulting in Swansea's involvement with the UK's Open University television-based courses and Barcelona's South American distance-learning activities.

Following these activities, both Swansea and Barcelona progressed from continuum-based problems to situations involving multi-fracturing solids. This area of research, as well as the related topic of particle methods, has proved to be most fruitful over the last two decades, with applications in many industrial sectors. These activities have led to a new series of conferences, initiated by Barcelona and Swansea, on particle-based methods. The first two were held in Barcelona and the third will be hosted by the University of Stuttgart in 2013.

Also, when coupled with the response of other physical phenomena, this methodology has provided an introduction to several new research areas, such as bio-engineering, nano-technology and the life sciences. These emerging areas will ensure that the

long term research collaboration between Swansea and Barcelona will continue to thrive.

## CONCLUDING REMARKS

My research work has led to extensive international research collaboration. Apart from allowing me to forge close friendship with many of the leading figures in the computational mechanics research community (I will deliberately not cite specific names, as I am certain to omit some important figures), I have developed long-term relationships with several institutions:

My relationship with the Departments of Civil and Mechanical Engineering at the University of Porto, Portugal goes back to the late 1960s, when I began to receive a series of PhD students from that university. To date, I have supervised ten PhD students from the institution, several of whom have gone on to be full professors in the university. I first visited the University of Cape Town (UCT) in 1980 at the invitation of Prof. J.B. Martin

and Prof. W.S. Doyle. Since that time I have visited the UCT on almost an annual basis and have witnessed the growth of the computational community there and the changes that have taken place in the post-apartheid era. Through links formed with Prof. Nenad Bicanic and Frano Damjanic, (a former PhD student, who sadly died of cancer in his early fifties) I have been involved with many EU –and British Council– sponsored research projects with the Universities of Split & Zagreb, Croatia.

My research activities have led to the supervision of some 70 PhD students, many of whom are now established researchers in their own right and hold academic and industrial positions at institutions worldwide. I will not attempt to mention individuals and will only say that a large proportion of my former students remain friends to the present day and it gives me great pleasure to meet them at international conferences and other events.

When I reached the, then, mandatory retirement age of 67 in 2009 I realized it was perhaps time to go for two reasons: First,



several of my former PhD students had already retired and, second, I realized that the father of one of my latest students had also been my PhD student. However, I am pleased to say that I have since then been retained by the university in a part-time position.

Although the past fifty years of computational modelling have proved to be exciting and rewarding, I believe that the future will be even more challenging. The PITAC (President's Information Technology Advisory Committee) Report published in 2005,



which was commissioned to determine the role of computational science in ensuring America's world-wide competitiveness in science and engineering, identified computational modelling as the third pillar of scientific progress. It recognises that computer simulation will play as important a role as theoretical developments and experimentation. The key conclusion of the PITAC report is that the most scientifically and economically promising research frontiers in the 21st century will be conquered by those most skilled with advanced computing technologies and computational science applications.

Universities world-wide are currently coming under increasing pressure to operate more efficiently on both teaching and research fronts. The rapid pace of progress also implies that education and professional training has, or will, become a lifelong activity, with a continuing need for engineers to update their competence and skills. Furthermore, most institutions are experiencing a shortfall in human skills, with an increasing scarcity of highly trained academic and technical people being evident. With this in mind, collaborative research and teaching programmes between universities within Europe, and indeed world-wide, is becoming an economic necessity to meet leading edge technological challenges. In this respect, I highly value my association with the UPC and hope to continue to foster these links for the foreseeable future. In addition to the more traditional research areas, many other topics are emerging, particularly in the life sciences and bio-medical engineering, and it is true to say that computational methods offer as many exciting prospects for development as they did some 50 years ago. In conclusion, I believe that we who have worked, and continue to work, in the field of computational modelling should feel privileged by the experience.

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# PARAULES DEL SENYOR ANTONI GIRÓ ROCA, RECTOR MAGNÍFIC DE LA UNIVERSITAT POLITÈCNICA DE CATALUNYA · BARCELONA TECH

Membres de la nostra comunitat universitària,  
Digníssimes autoritats acadèmiques,  
Sr. secretari general del Consell Interuniversitari de Catalunya,  
familiars, amics i companys del professor Owen,  
senyores i senyors que ens acompanyeu en aquest acte,  
Dear Professor Roger Owen,

Vull en primer lloc agrair-vos la vostra presència i manifestar també l'agraïment de la Universitat Politècnica de Catalunya al Departament de Resistència de Materials i Estructures a l'Enginyeria per haver presentat aquesta proposta, que va ser aprovada per unanimitat pel nostre Consell de Govern. Les meves felicitacions també al professor Oñate per la seva magnífica *laudatio* als mèrits del professor Owen, i al CIMNE, pel seus primers 25 anys d'intensa i exitosa activitat. Per acabar, el meu agraïment,



com és obvi, al nostre nou doctor *honoris causa*, el professor Owen, per les seves paraules. Thank you very much for giving us a snapshot of your life and your exciting experiences. Your description of the importance of the analysis of problems in fracturing was fascinating. Particularly impressive was the case of the pilot who managed to land his plane on one wing!

We are very proud and happy to welcome Professor David Roger Jones Owen as a new member of the academia of the UPC. Honorary doctorates are awarded by our university to distinguish individuals who have played a leading role in their field, either by being eminent scientists and academics, or by having contributed with their work to the development of society, and in particular, the UPC.

Professor Owen is one of the few extraordinary cases in which the same person gathers all these attributes. He is a prestigious scientist who has made important contributions to the field of computational mechanics. He is also a fine academic, an excellent teacher and a mentor of some 70 PhD students. Last, but not least, his work has been seminal in the development of



computational mechanics worldwide, and, in particular, at the CIMNE and the Barcelona School of Civil Engineering.

His entrepreneurship in creating and developing the company Rockfield Software Limited, twice acknowledged by the British Queen for being an innovative and successful international enterprise, is a good example and a model from which we will surely extract many ideas for promoting new spin-off companies at our university.

The many merits of Professor Owen clearly warrant his becoming an honorary doctor of the UPC. This award also recognises and expresses our gratitude for his continuous involvement and support to the UPC's very many scientific activities and projects over 30 years.

Our university is committed to excellence in research, as well as to innovative ways of educating our graduate and postgraduate students, so that they can be better prepared for challenges in their future careers.

Numerical and computational methods and their applications provide us with a world of opportunities to generate new ideas for promoting innovation in Higher Education Institutions and Enterprises. These techniques will also allow us to develop new methods and approaches for making teaching and learning more attractive, in order to facilitate the professional development and competitiveness of our graduate students throughout their professional life.

This is a task that we should not and cannot do alone, but in partnership with many colleagues and organisations in Europe and worldwide. Examples are the 25 or so international Master of Science courses carried out with the support of the European Commission's prestigious Erasmus Mundus programme.

One of these master's degrees, the Master of Science in Computational Mechanics, is offered jointly by the UPC and Swansea University, together with the universities of Nantes and Stuttgart. This is another example of the UPC's many fruitful rela-

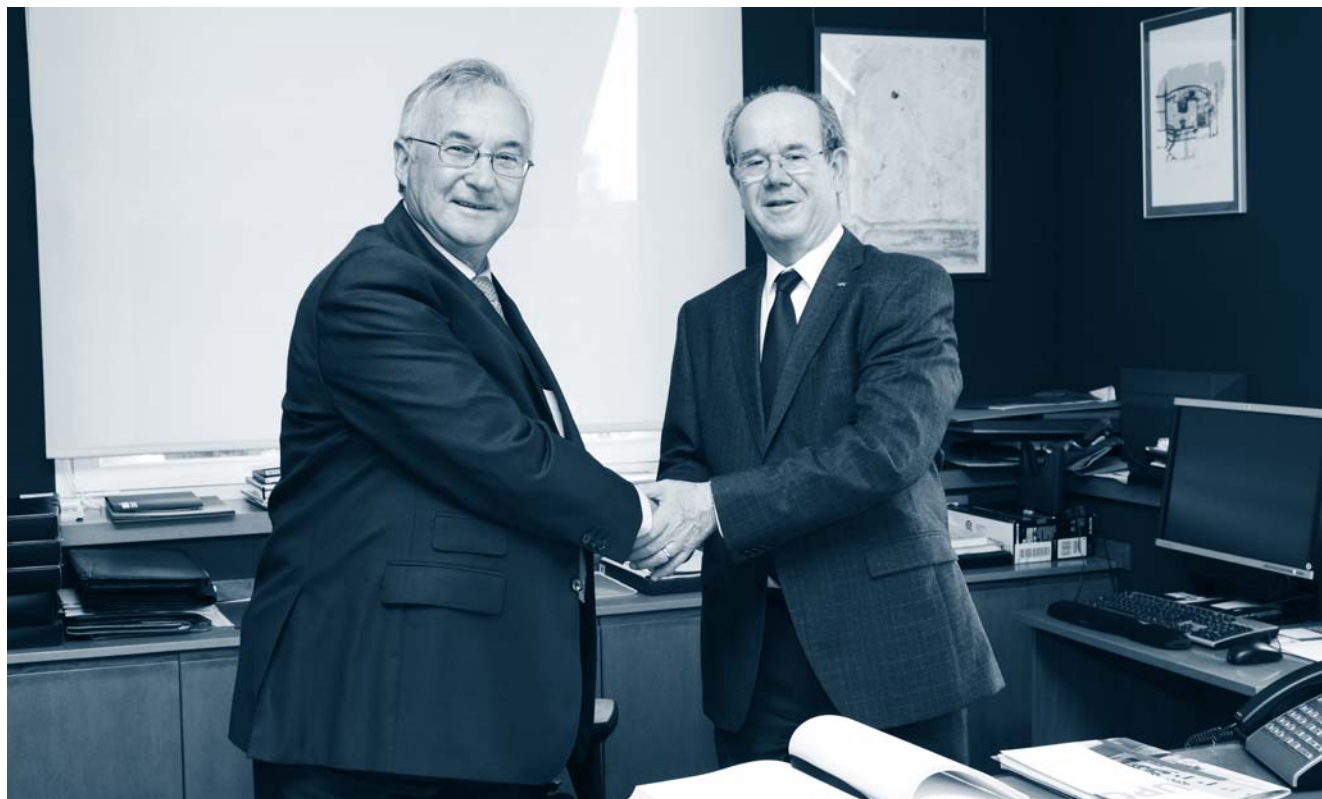
tionships with Swansea University, which I hope will continue, and even increase, in the future.

Professor Owen, I have had the opportunity to greet you at the opening of many COMPLAS conferences. Today it's my great pleasure to welcome you as a doctor of the UPC.

We thank you for your support and for your friendship with our university, and we look forward to continuing to interact closely with you for many years to come.

A continuació, acomiadarem aquest acte escoltant dempeus el *Gaudeamus igitur*, interpretat per la Coral Arquitectura i l'Orquestra de la UPC, a les quals agraïm que, com sempre, ens hagin volgut acompanyar. Finalment, un sincer agraïment a totes les persones que heu treballat perquè aquest acte s'hagi pogut acomplir.

Thanks very much to you all. Moltes gràcies.





Acte d'investidura Doctor *Honoris Causa*  
Roger Owen

Dr. Roger Owen  
Doctor *Honoris Causa*

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