From Bynea to Barcelona
A Celtic/Catalan Odyssey

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Introduction

The connection between Swansea University and Universitat Politecnica de Catalunya (UPC), Barcelona extends over 35 years, commencing with the arrival at Swansea of Eugenio Onate in 1976 to undertake Ph.D. 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 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 provide some insight to my long term association with UPC.

The Early Years

I was born on 27th 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.

Figure 1. The family home – second left

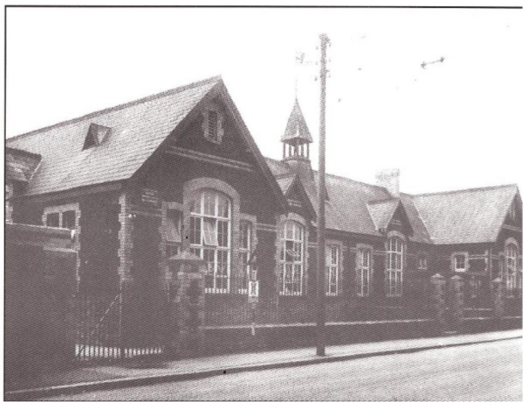


Figure 2. Bynea primary school

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 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 who, 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 my initial education 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 that 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 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 Masters, 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 Ph.D. 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 Ph.D. 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. Through 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 and 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 that is still in print and was in the future 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 modeling 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 lead 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

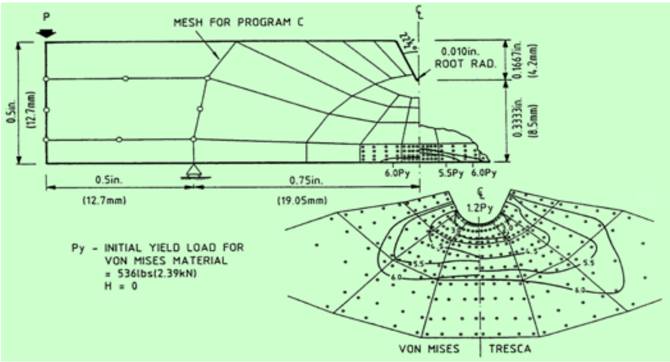
My research, in the field of solid and structural mechanics, has centred on the development of solution procedures for non-linear problems encountered in science and engineering. This work, which is predominantly computationally based, encompasses fundamental constitutive modelling, algorithmic developments,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

I completed my Ph.D. 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, describes the development and application of the method to the case of a notched bar in bending and deserves mention as 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.



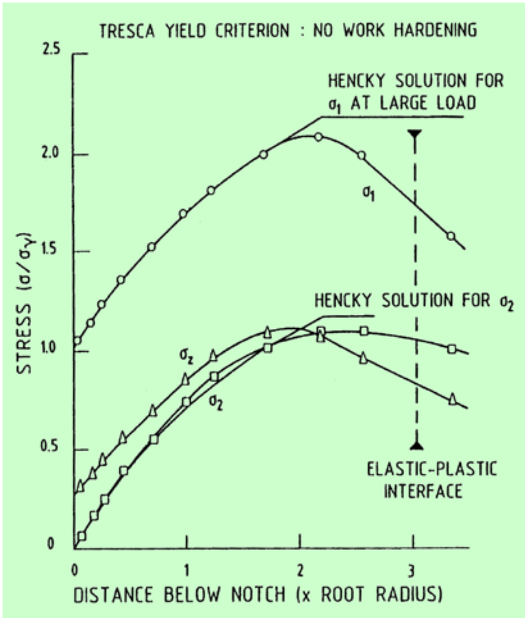


Figure 3. Elasto-plastic analysis of a notch-bend specimen showing the mesh and geometry employed, and illustrates the departure of the numerical prediction from the Hencky solution, which had previously been considered to be exact.

My research in the late eighties and nineties moved on to the computational treatment of elasto-plastic problems involving finite strains. At this time, 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 Ph.D. 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 Refs [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 include the modelling of strain localisation phenomena in both classical and Cosserat continua [10].

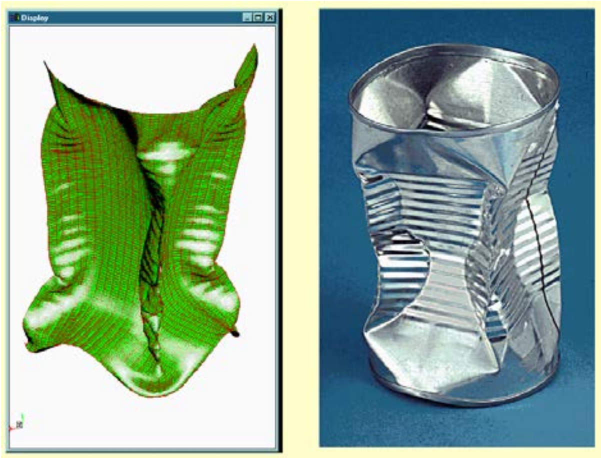


Figure 4. Elasto-plastic large deformation container forming simulation.

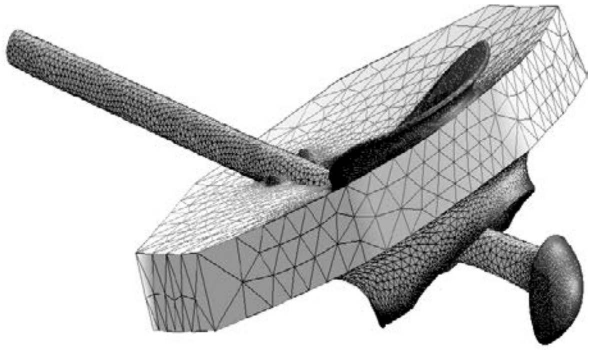


Figure 5. Oblique missile impact on a steel target.

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; e.g. [17] and references therein. Based upon this methodology, contributions have been made to fundamental understanding in several key application areas; including explosive simulations which necessitates coupling of the multi-fracturing solid behaviour with the evolving detonation gas distribution, defence problems related to high velocity impact involving the

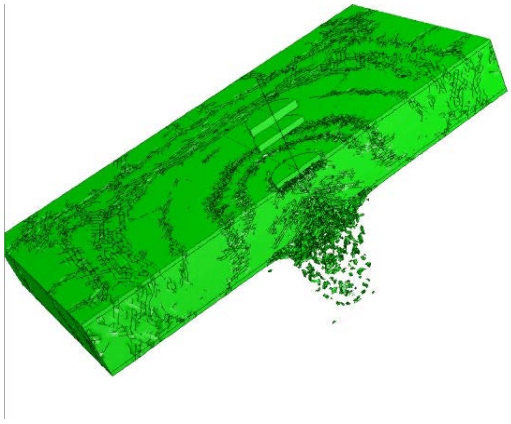


Figure 6. Missile impact on a reinforced concrete plate.

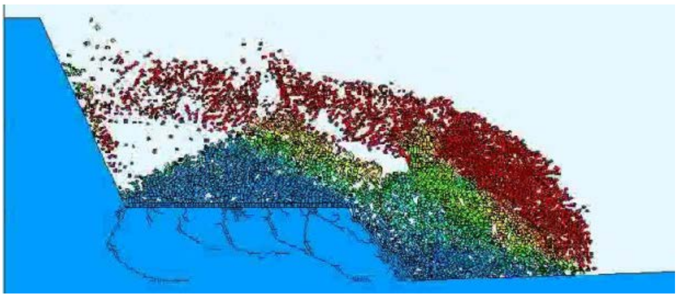


Figure 7. Bench blasting - explosive mining simulation.

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 Ph.D. degree with Olek Zienkiewicz, working in the area of metal forming. After receiving his Ph.D. 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 modeling 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 previous 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 UPC.

From the early eighties 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, firstly, quadratically convergent procedures for elasto-plastic problems, followed by the treatment of finite deformation conditions. This was an extremely exciting decade in computational modeling, with many innovative algorithms and approaches being generated. These developments resulted in 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 lead 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 in the series 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 lead 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 sixties when I began to receive a series of Ph.D. students from the university. To date, I have supervised ten Ph.D. 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* in 1980 at the invitation of Prof. J. B. Martin and Prof. W. S. Doyle. Since that time I have visited 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 Ph.D. 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 lead to the supervision of some 70 Ph.D. 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: Firstly, several of my former Ph.D. students had already retired and secondly I realized that the father of one of my latest students had also been my Ph.D. 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 equally an important 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 becoming 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 UPC and hope to continue to foster these links for the foreseeable future. In addition to the more traditional research areas, many other topics, particularly in the life sciences and bio-medical engineering, are emerging and it is true to say that computational methods offer as many exciting prospects for development as they did some fifty 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.

Selected Publications

1 D. R. J. Owen, Solutions to arbitrarily oriented periodic dislocation and eigenstrain distributions in a half-space. Int. J. Solids & Structures, Vol. 7, pp. 1343-1361, 1971.

2 J. R. Griffiths and D. R. J. Owen, An elastic-plastic stress analysis for a notched bar in plane strain bending. J. Mech. Phys. Solids, Vol.19, pp. 419-430, 1971.

3 D. R. J. Owen and E. Hinton, Finite Elements in Plasticity: Theory and Practice. Pineridge Press, 1980.

4 T. Kant, D. R. J. Owen and O. C. Zienkiewicz, A refined higher-order Co plate bending element. Comp. & Structures, Vol. 15 (2), pp. 177-183, 1982.

5 D. R. J. Owen and J. A. Figueiras, Anisotropic elasto-plastic finite element analysis of thick and thin plates and shells. Int. J. Num. Meth. Engng. Vol. 19, pp. 541-566, 1983.

6 D. R. J. Owen and Z. H. Li, A refined analysis of laminated plates by finite element displacement methods - I. Fundamentals and static analysis - II. Vibration and Stability. Comp. & Structures, Vol. 26, pp. 907-923, 1987.
7 D. Peric, D. R. J. Owen and M. E. Honnor, A model for finite strain elasto-plasticity based on logarithmic strains: Computational issues. Comp. Meth. in Appl. Mech. & Engng, Vol 94, pp.35-61, 1992.
8 D. Peric and D. R. J. Owen, Computational model for 3-D contact problems with friction based on the penalty method. Int. J. Num. Meth. Engng. Vol 35, pp 1289-1309, 1992.
9 H. E. Evans, G. P. Mitchell, R. C. Lobb and D. R. J. Owen, A numerical analysis of oxide spallation. Proc. R. Soc. Lond. A 440, 1-22, 1993.
10 D. Peric, J. Yu and D. R. J. Owen, On error estimates and adaptivity in elasto-plastic solids : Applications to the numerical simulation of strain localisation in classical and Cosserat continua. Int. J. Num. Meth. Engng., Vol. 37,pp. 1351-1379, 1994.
11 A. Munjiza, D. R. J. Owen and N. Bicanic, A combined finite/discrete element method in transient dynamics of fracturing solids. Int. J. Engng Comp., Vol. 12, pp. 145-174, 1995.
12 E. A. de Souza Neto, K. Hashimoto, D. Peric and D. R. J. Owen, A phenomenological model for frictional contact of coated steel sheets accounting for wear effects : Theory, experiments and numerical simulations. Phil. Trans. Roy. Soc. Lond. A, Vol 354, 1-25, 1996.
13 D. Peric, Ch. Hochard, M. Dutko and D. R. J. Owen, Transfer operators for evolving meshes in small strain elasto-plasticity. Comp. Meth. Appl. Mech. Engng. Vol. 137, pp. 331-344, 1996.
14 Y. T. Feng, D. Peric and D. R. J. Owen, A non-nested Galerkin multi-grid method for solving linear and nonlinear solid mechanics problems. Comp. Meth. Appl. Mech. & Engng., Vol. 144, pp. 307-325, 1997.
15 D. Peric and D. R. J. Owen, Finite element applications to the nonlinear mechanics of solids. In:Reports on Progress in Physics, Institute of Physics, Vol 61, N0. 11, pp. 1495-1574, 1998.
16 P. A. Klerck, E. J. Sellers and D. R. J. Owen, Discrete fracture in quasi-brittle materials under compressive and tensile stress states. Comp. Meth in Appl. Mech & Engng. Vol. 193: pp. 3035-3056, 2004.
17 D. R. J. Owen, Y. T. Feng, E. A. de Souza Neto, M. Cottrell, F. Wang, F. M. Andrade Pires and J. Yu, The modeling of Multi-Fracturing Solids and Particulate Media, Int. J. Num. Meth. Eng., Vol. 60(1): pp. 317-340, 2004.
18 F. M. Andrade Pires, E. A. de Souza Neto and D. R. J. Owen, On the finite element prediction of damage growth and fracture initiation in finitely deforming ductile materials. Comp. Meth in Appl. Mech & Eng. Vol. 193, pp. 5223-5256, 2004.
19 Y. T. Feng, K. Han and D. R. J. Owen, Coupled lattice Boltzmann method and discrete element modeling of particle transport in turbulent fluid flows: Computational issues, Int. J. Num. Meth. Engng., Vol 72, pp 1111-1134, 2007.
20 C.F. Li, Y. T. Feng, D. R. J. Owen and I. M. Davies, A Fourier-Karhunen-Loève representation scheme for wide-sense stationary stochastic fields. Int. J. Num. Meth. Engng. 73(13), 1942-1965, 2008.
21 E. A. de Souza Neto, D. Peric and D. R. J. Owen, Computational Methods for Plasticity: Theory and Applications. John Wiley & Sons, Chichester, 2008.