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OBITUARY

JOHN ARGYRIS

John Argyris, Professor Emeritus, Stuttgart University and University of London, died on 2 April 2004 in Stuttgart at the age of 91. Born on 19 August 1913 in Volos, Greece, he was educated in Civil Engineering at the Technical Universities of Athens and Munich. He then assumed a position in industry (J. Gollnow & Son, Stettin) where, between 1937 and 1939, he carried out theoretical and experimental research and worked on the design of steel and light alloy structures. In 1941–1942, he took a post-graduate course in Aeronautics and Mathematics at the Technical University of Zurich. He was with the Royal Aeronautical Society from 1943 to 1949 and at the University of London, Imperial College of Science and Technology, as Senior Lecturer in 1949, Reader in the Theory of Aeronautical Structures from 1950 to 1955 and Professor of Aeronautical Structures between 1955 and 1975. He was appointed Professor at Stuttgart University in 1959, acting as the Director of the Institute of Statics and Dynamics of Aerospace Structures between 1959 and 1984, and was subsequently Director of the Institute of Computer Applications from 1984 to 1994.

When Professor Argyris started in Stuttgart, he was decisively involved in establishing the new Faculty of Aerospace Engineering and making it as advanced as possible: not élite, but outstanding in education and research. After the basic courses, a small select number of motivated students was educated in the most relevant disciplines, such as Aerodynamics, Thermodynamics, Aircraft Propulsion, Aircraft Construction, and Structural Analysis. In the late 1950s and early 1960s, at the beginning of a first tentative renaissance of aerospace activity in Germany, the students were intentionally provided with a profound fundamental knowledge in aircraft engineering on a high level. This was acknowledged by other industrial branches: the graduates were able to employ and disseminate innovative methods in their professional careers. For good reason, focusing on fundamentals has remained the educational principle of the Faculty, despite the multitude of scientific disciplines which now make up Aerospace Engineering and the vastly increased number of students.

Imperial College was at rather a mythical distance for Argyris' students in Stuttgart. They became aware of his duties there, missing his vivid and exacting lectures. He himself maintained a strong association with Imperial College, to which he remained committed as a visiting Professor between 1975 and 1978, and thereafter. Previous research work and training experience reflected beneficially on the courses delivered with the assistance of an international team which had followed him to the Universität Stuttgart. The comprehensive analytical research work performed at the Royal Aeronautical Society on elements of the elastic aircraft was included as part of the Handbook of Aeronautics No. 1 in the early 1950s. The work on energy theorems and ongoing matrix methods for structural analysis undertaken at Imperial College, documented in a series of articles in Aircraft Engineering in the mid-1950s, appeared as a book in 1960 and was received with such interest that a fifth edition had to be printed in 1977. This respectable background, along with the appealing presentation in matrix notation of the dual force and displacement methods in Ingenieur Archiv in 1957, raised interest in the novel methods that attracted the attention of students and frequently also researchers to the courses. But beyond lecturing, the Professor preferred training the students and possibly involving them in research work. As a rule, he appreciated individual personality and work performance higher than scores.

The utilization of the digital computer was the target from the very beginning. Recognizing its significance as an amplifier of human intelligence rather than as an arithmetic machine, Argyris set himself the task of posing the physical problem appropriately, as expressed in *The Computer Shapes the Theory*, a lecture delivered to the Royal Aeronautical Society in 1965. His Institute of Statics and Dynamics (ISD) was mainly devoted to the research and development of computer methods for structural analysis. The formation of the appended Computation Unit for Aircraft Engineering was the nucleus for the development of the Regional Computing Centre at the University. Stress analysis, the subject of prime interest, and the restricted capacity of the digital computer at that time had favoured elaborating the force method first. The high standards achieved in London, with contributions from Stuttgart, are documented in the book *Modern Fuselage Analysis and the Elastic Aircraft*. However, the realization of an increasing computer capacity that rapidly shifts limits was decisive in then advancing the displacement method, capable of complete automation in the computer. For years in Stuttgart, the development of the automatic system for kinematic analysis (ASKA) provided the unifying frame for diverse research activities in the areas of finite elements, solution techniques and software. Apart from linear elasticity, geometrical non-linearity and plasticity were touched upon at an early stage. The evolvement of ASKA to a general-purpose system in the 1970s and its world-wide utilization for engineering applications in elasticity, dynamics, plasticity, buckling, and later in fracture mechanics and steady viscous flow, benefited from collaboration with the aerospace industry and other partners both in Europe and overseas.

The reputation of the Institute was attracting researchers from various countries as well as graduates and students to join the innovative work with the inspiring Professor Argyris. The heterogeneous scientific family, unified by an enthusiasm for the advancement of computational methods in mechanics and engineering, was subject to fluctuations, but grew at one stage to over 100 members. The 1st Conference on Matrix Methods in Structural Mechanics, Dayton, OH, held in 1965, can now be considered to mark the end of the pioneering era in the field. The opening address *Continua and Discontinua* highlighted the results of the extensive work performed at the Institute up to then. Then began a period of research on and with finite elements—replacing the term matrix methods—that was far-ranging both thematically and geographically.

The 1970s were devoted to intensive research in the field of non-linearities along with the development of dedicated methods and software. The natural approach conceived earlier by Argyris proves best suited for modelling in the kinematically non-linear range. It is based on an *ab initio* distinction between rigid displacements and deformation modes of the element. The local state of strain, defined for the elementary triangle in the plane and for the elementary tetrahedron in space, is measured along the sides and the edges of the elements, respectively. The result is a homogeneous description with reference to a system that follows the motion and deformation of the material. In conjunction with the sub-element technique, it allows the treatment of higher-order elements as well. Apart from formal elegance, the computer implementation is simple and advantageous for the arithmetic. The method complies with the guiding principle that the mathematical formalism should evolve from the nature of the task to be performed rather than be imposed on it. Furthermore, geometrical description and energy concepts have been considered to best suit the engineering point of view (*μηδεις αγεωμετρητος εισιτω, Πλατων*).

Fundamental thoughts on the natural methodology exposed in *Recent Advances in Matrix Methods for Structural Analysis*, 1964, were consistently extended from structural mechanics to the mechanics of solid continua, heat flow, and fluid dynamics up to the mid-1980s. The form-finding for the suspended cable roof of the Olympic Stadium in Munich in 1972 was an impressive demonstration of the powerful technique. The highly non-linear problem resulted in 11 000 unknowns. Circumstances dictated an *ad hoc* individual solution on the computer; this was realized from scratch at the Institute within a few weeks. A period was initiated which was dedicated to pronouncedly non-linear problems in statics, dynamics, finite strains in elasticity and plasticity. Industrial requirements and tasks actually posed by engineering practice motivated the development of theory and software. The memorable conferences on Finite Elements in Non-Linear Mechanics (Fenomech), organized and held in Stuttgart in 1978, 1981 and 1984, provided an international forum for the presentation of advances in the field and the exchange of experience and thoughts between experts. The contribution of the Institute to Fenomech ’78 documented the high standard of the natural technique achieved up to that time in structural engineering. In 1981, the field of large-strain elastoplasticity could be presented with a degree of maturity as also the issue of thermomechanically coupled deformation processes. In non-linear elastic structures, progress was reported on static and dynamic stability under non-conservative loading, and comprehensive theoretical work on large rotations appeared in a refreshing treatise on the subject.

The last Fenomech in 1984 marked a significant change that had occurred steadily but with ever-increasing speed over the preceding years: the computer had facilitated thinking in more global spaces, sparking the interest of the analyst to overcome the limitations of his original research topic and to enter new areas even as a trainee. At the ISD, existing experience in modelling potential flow, plasticity, and viscous deformation—with pioneering research and development in superplastic forming for the European aerospace industry—led naturally on to an extension to fluid dynamics. The paper presented to the Conference entitled *Τα παντα ρει* (*Ηρακλειτος*) offered a survey of the most recent developments in the natural methodology in the field of flow phenomena occurring in the Stokesian motion of solids, and fluids described by the Navier–Stokes equations, multifield problems and fluid–solid interaction included. This work marked the final days of the traditional Institute of Statics and Dynamics in Stuttgart.

John Argyris received the status of Emeritus Professor of the Faculty of Aerospace Engineering, but his will to continue scientific research in new directions was *constant as the Northern Star* (Shakespeare). In recognition of the expanding trend in computer simulation, Stuttgart University founded the Institute of Computer Applications (ICA) which, with Professor Argyris as its Director from 1984 to 1994, soon became famous for its research and developments in engineering and science. Interdisciplinary research on an international level was characteristic of the new institution, the projects ranging from the micro-mechanics of materials to re-entry aerodynamics within the European Hermes Programme, and the utilization of novel computer architectures such as the multiprocessor ones which led to the renaissance of the sub-structuring technique already invented in the 1950s. First results could be reported in contributions to the 2nd World Congress on Computational Mechanics (WCCM II), hosted by the ICA in Stuttgart in 1990. An outstanding presentation by the Institute concerned studies on chaotic phenomena, a subject that fascinated Argyris for years and concluded with the publication of a textbook in 1994.

Apart from his eagerness for innovation, he felt obliged to collect the material on the finite element method that had been the subject of work at the former ISD in a textbook addressed to students and engineers. The three volumes on his view of the finite element method as advanced in Stuttgart appeared in German in 1986, 1987 and 1988. An English edition of the third volume on dynamics, with a chapter devoted to chaos, was published in 1991.

These few highlights should not eclipse the continuous work of the institutions which he led and inspired. The talent of motivating high-quality research work—apparently with facility, intuition for individual skills, and always receptive for proposals and new ideas—is documented in about 400 papers. A great part was published in Computer Methods in Applied Mechanics and Engineering, founded with William Prager in 1972, now one of the most highly reputed journals in the field. Progress in work was reported at international conferences, where Argyris was in demand as a lecturer, both for the scientific content of his contributions and for his clear and spirited manner of presentation. No theory without verification by results, and no results with the theoretical background hidden. The beauty of the computer graphics, generally admired, occasionally gave rise to objections during the transitional period to what has now become a common method of presentation.

Younger engineers, who have grown up with the computer and been educated since computational methods became standard procedures, are in a position to move with ease from stress analysis to tasks of higher complexity such as structural design, system analysis—including multiphysics—and process simulation. This is an achievement based on the research and development of computational methods initiated by a few men, cognizant of theory and practice, conscious of the limitations and striving for innovation. One of these men was John Argyris. For his exceptional contributions to computational mechanics in particular and his outstanding research work in general, he was entitled to distinctions. The fellowship to the Royal Society (F.R.S.), 1986, and to the Royal Aeronautical Society (F.R.Ae.S.), from 1955 onward, are but two of the numerous distinguished memberships, not to mention awards, prizes and medals as well as honorary academic titles. He was impressed by the work and personality of Théodore von Kármán: he must have considered it a particular honour to receive the von Kármán Medal, the highest scientific award of the American Society of Civil Engineers, New York, in 1975. He highly respected Stephen Timoshenko, whose classic book he recommended to students as the gospel on elasticity: in 1981, he received the Timoshenko Medal, the highest scientific award of the American Society of Mechanical Engineers, New York. But this is only part of an extensive list.

Ever devoted to academia, Professor Argyris did not take leave of his office even after the ICA was re-structured in 1994. He came in as long as possible, now with a pronounced interest in physics. The work of John Argyris had a unique impact on the advancement of computer methods in applied mechanics and engineering. His continuous, creative work (*Της δ'αρετης ιδρωτα θεοι προπαροιθεν εθηκαν Αθανατοι, μακρος δε και ορθιος οιμος ες αυτην. Ησιοδος: Εργα και ημεραι*) has left its mark on science, his personality on those who met or worked with him. His accomplishments can hardly be appreciated adequately, nor his achievements be assessed. His spirit was beyond and above all that most of us know of him.

IOANNIS DOLTSINIS
University of Stuttgart, Germany

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