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ADVANCES IN COMPUTATIONAL STRUCTURAL MECHANICS

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Abstract. *In this report some new advances in computational structural mechanics presented at the Fourth International Conference on Computational Structures Technology (here CST'98) August 18 to 20 1998 - Edinburgh, Scotland, are described. The conference was organized by Civil-Comp Press from Edinburgh. It convened about 150 selected scientist, researchers and professionals from computational mechanics, computer science and related areas to advance the state of the art in the developing of reliable and efficient computational structures technology procedures.*

1. THE SCOPE OF THE CONFERENCE

This was a fourth time that the researches from all side of the world congregated to share ideas and solutions applicable to almost any kind of design. The conference was held in the wonderful surroundings of the Scotland's capital city of Edinburgh during the worldwide famous festivals times in August.

The aim of the conference was to bring together researches in computational mechanics and software developers in the field of solid mechanics. The main goal of the conference was to present new advances in the reliable numerical simulation of real mechanical systems, with special emphasis on implementation and application. Further, attention was paid to fostering a common understanding of the nowadays needs and demands posed in front of the computational mechanics procedures, techniques and actions. The Conference proceedings are printed in a form of four books with a catalogue records available from the British Library.

About 150 speakers and attendees provided a brief overview of recent advances in various topics. These are related to finite element procedures and techniques, civil and structural engineering computing for practice, engineering computational technology and computational structural mechanics. Attendees came (in alphabetical order) from Australia, Austria, Bangladesh, Brazil, Canada, Chech Republic, China, Croatia, Egypt,

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France, Greece, Germany, India, Israel, Italy, Iran, Ireland, Japan, Korea, Macedonia, New Zealand, Spain, State of Bahrain, Palestine, Poland, Portugal, Sweden, Switzerland, Taiwan, Turkey, United Kingdom, United States of America and Yugoslavia.

The conference program contained the following topics: Structural dynamics, multy-body systems, parallel and distributed computations, finite volume calculations, boundary elements methods, mixed finite element approaches, numerical and solution procedures, element technology, analysis of plates, contact and impact problems, bio-mechanics problems, fluid-structures interactions problems, design and analysis of steel structures, design and analysis of connections, neural computing for engineering computations, mesh generations, error estimations, adaptivity, crack modeling with adaption, composites, fracture mechanics, object oriented technology, knowledge-based systems, soil-structures interactions problems, genetic and simulated annealing algorithms for engineering computations, design loading, modeling of reinforced concrete, plastic and elasto-plastic modeling, design and analysis of geotechnical structures, computational software developments.

Looking back at the conference, most of the lectures were concerned with implementing the known and new computational procedures in solving the real mechanical problems. Solutions of some of these problems are supported by miscellaneous Projects currently running in European Union Community.

The hosts of this conference was Heriot-Watt University, one of the three universities in Edinburgh. It was founded in 1821 as a School of Arts and Mechanical Institute. It became in 1854 the Watt Institution and School of Arts, and from 1885 was the Heriot-Watt College until its elevation to university status in 1966. Its Science Park has a close working relationship with commerce. Many of the Heriot-watt students come from abroad and there is a close connection with a Norway for example [1]. All lectures were held at the Mechanical and Chemical Engineering department. The chairman of organizing committee was professor Barry H.V. Topping, from the same department. Among his many successful activities he is an editor in chief of the international journal "Computers and structures".

From our country there was a only one paper "On the efficiency of the primal-mixed finite element scheme" [5] by the present author and professor Mladen Berkovic also from Faculty of Mathematics, Belgrade. The paper is included in the book "Advances in computational structural mechanics" edited by B.H.V Topping and published by Civil-Comp Press UK.

2. THE OVERVIEW OF THE CONFERENCE

Overview of the Conference will be done trough a brief review of lectures presented at the conference CST'98, with special emphasis on opening plenary lectures were given by several respected scientists.

The first one was given by Professor A.K. Noor, from the Centre for Advanced Computational Technology, NASA Langley Research Centre, Hampton and University of Virginia, USA. The title of his lecture was "ISE-Intelligent Synthesis Environment for Future Aerospace Systems and its Impact on Engineering Research and education." The ISE environment is developed by NASA, the University of Virginia and the Jet Propulsion Laboratory. Its main purpose is enhancing the fast design and missions

procedures that are optimal in the ratio of the cost-efficiency. "...ISE uses a synergistic combination of leading edge technologies, including high performance computing, high capacity communications and networking, human centered computing, knowledge-based engineering, computational intelligence, virtual product development and product information management...". Under the high performance computing, an adaptive or configurable computing systems are explained. Such a kind of computing systems have information processing elements that can change and adapt their hardware circuits based on the type of the problem that have to be solved. Further, quantum computing is based on quantum parallelism logic that allows exponentially many computations to take place simultaneously. Next, chemical and biochemical computers were explained, where molecules are used as the active components in a computer circuit.

For example DNA computers, albeit much more slower than conventional electronic computer, are well suited for combinatoric problems. Finally, optical and optoelectronic computers in the future will take a part as an interconnections network at the hart of electronic computers. Also, special attention is drawn to the powerful microprocessors and visual computers, with motion-video instructions from which is expected to significantly enhance the capability of desktop multimedia PC, for example for visual communications. It is expected that for the September 1999 Intel and Alpha processors with MVI instruction facilities will reach 600 and 1200 MHz, respectively. The next component of the ISE is rapid synthesis and simulation tools. Many of the ISE tools are provided by commercial modeling and simulation system and CAD/CAM/CAE suites.

Further distinguish characteristics include seamless interfaces from CAE systems to the virtual environment and associated soft computing tools to solve complex design problems with system uncertainties together with the real time generation of a model. The ISE component that covers life-cycle integration and validation has four subelements: engineering process assessment, integration methods, large scale research and development applications and large scale projects and demonstrations.

Interesting is that large scope numerical simulation involving diverse geographically dispersed teams will be perform in testbeds. As a concluding remark professor Noor has said that universities can work with industry, government labs and professional societies in developing effective instructional and training facilities for the new research and synthesis approach [2].

The second plenary lecture named "Advances in analysis of structures and fluid-structures interactions" was given by professor Klaus J. Bathe from Massachusetts Institute of Technology and who is a general director of Adina R&D Inc USA also. The lecture started with the observation that has been amply recognized that many problems in solid and fluid mechanics cannot be solved efficiently using finite element discretisation with only one unknown variable. The solution is the finite element formulation based on the mixed principle. In the mixed formulations several fields of interests are simultaneously approximated. For example in the solid mechanics displacement and stress, or displacement, deformation and stress and in the fluid mechanics displacement and pressure. However, the key to whether a mixed formulation is actually valuable lies in the convergence properties of the formulations. Unfortunately, on the first glance, convergence criteria are not obvious as it is in the primal formulations. In his paper a rather simple convergence criteria in the form of a numerical test is given. This test actually represent the known inf-sup test related to the saddle point problems [3].

The third plenary lecture was in the section of the Forming problems, under the name "New trends in the finite element modeling of metal forming process" by professor J.L. Chenot, School of Mines Paris, France."...The main constitutive equations describing the mechanical behavior of metal are recalled with usual friction laws modeling contact at the tool part interface and the thermal coupling for hot forming. Automatic remeshing is compulsory to model a large strain which are usually produced by forming process. Adaptive refinement must also be considered if one wishes to control the accuracy during the whole deformation....Inverse method are also investigated in the field of the metal forming and their application to computer aided rheology....".

Professor Earnest Hinton from Department of Civil Engineering, University if Wales Swansea, United Kingdom gave us a lecture named "On the reliability of optimized shells". "Shells are analyzed using shape and size optimization and numerical approximation is based on linear elastic small displacement Reissner-Mindlin shell models. Once the optimal shape and thickness distributions have been determined, the nonlinear buckling loads of the initial and optimized shells are investigated using a geometrically nonlinear analysis tool capable of dealing with complex load-displacement paths including snap-trough and snap back..." [4].

Professor H.S. Turkman from Istanbul Technical University held a lecture "Structural response of isotropic plates subject to blast loading". Paper is also concerned with the presenting correlation between the theoretical analysis and the experimental results of the strain time histories. The plate is clamped at its all edges. The equation of motion are derived by the use of the virtual work principle within the framework of the Love's theory of thin elastic shells. A finite element analyses is presented and the effects of material properties are examined on the dynamic behavior.

Professor G. Thierauf from University of Essen, Germany, presented a lecture "Optimum design of reinforced concrete structures". The natural draught cool tower is analyzed. A parallelization concept, applied on the eight processors, is presented in the stage of gradient calculation. Examples are included to illustrate the practical use and the time efficiency of the parallelization in the area of engineering design.

Professors R. Push from Geodevelopment Ideon Research centre applied Sweden and R.A. Addey from UK presented a lecture "Accurate computation of stress and strain of rock with discontinuities". Repository concept for the deep disposal of radioactive waste demand a deposition tunnels and holes at the several hundred metros depth. A numerical study of the resulting stress state at the intersections of the tunnels is presented and the impact of discrete weakness predicted.

Professors E. Deletombe and B. Malhebre from ONERA Lille France presented a lecture "Fluid Structure Simulation of Hydraulic Ram Pressure in Fuel Tanks". An original method has been developed to study the fluid/structure interaction problem of hydraulic ram pressure generated by bullets penetrating fuel tanks. The basic idea consists in modeling the bullet by an equivalent conic projectile, the radius of which (not the tumbling angle) varies accordingly to a reference drag coefficient evolution.

The present author held a lecture with the name "On the efficiency of the primal-mixed finite element scheme". In the paper a coordinate independent finite element primal–mixed approach based on the stationary Reissner's principle, having both the displacement and stress boundary conditions exactly satisfied and solvable by direct Gaussian elimination procedure, is presented. The main goal of this paper is to show that the proposed procedure is easy for implementation, robust and more efficient, in the

sense of the execution time needed for the prescribed accuracy, than classical displacement finite element procedure. Furthermore it has been shown, that the present approach is stable near singularities, at variance with some other closely related procedures. In order to illustrate the efficiency of the present primal–mixed finite element method two–dimensional plane stress linear isotropic elastic model problems were examined. It can be concluded that mixed elements with complete continuity can be practically realized, in addition simple and clear measures for the enhancement of the stability of a solution of the resulting equations are available, and finally the present mixed procedure is about two orders of magnitude more efficient than the classical finite element analysis. As it can be seen, the subject of the paper satisfy main demands posed in plenary lectures. It is a special encouragement for the future research especially in the three-dimensional mechanical problem situation, where for example, excellent prediction of shell (observed as a full solid body) behavior is expected.

Some of the members of the conference editorial board were professors H. Adeli USA, K. J. Bathe USA, T. Belytschko USA, D.E. Beskos Greece, C. S. Desai USA, P. Hajela USA, E. Hinton USA, M. Kleiber Poland, E. Onate Spain, M. N. Pavlović UK, B.A. Szabo USA.

Among the number of researches participated this conference I want to mention professor Sankaran Mahdevan from Vanderbilt University, Nashville USA & NASA, Professor Georg Thierauf from University of Essen Germany, Dr John P. Wolf from Swiss Federal Inst. Of Technology, Lausanne, Switzerland, professor. Demetres Briassoulis from Agricalture University of Athens and professor A.Kaveh I.U.S.T. Teheran, Iran, as well as Rosemary Brodie from Civil-Comp Edinburgh UK.

3.CONCLUSIONS

Attendance at "The Fourth International Conference on Computational Structures Technology" even more strengthened my impression that computational mechanics is considered as a field of a top priority and of vital importance for the economy and security of many countries. Further, the relevant position of the current state of the computational mechanics in our country, viewing from the available manpower and technical recourses is satisfactory, but not yet widely recognized as an irreplaceable cheap and fast analysis and design tool. From that point of view, attendance at this conference has been inspirative and important for a future research.

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DOSTIGNUĆA U RAČUNSKOJ MEHANICI STRUKTURE

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Nova dostignuća u računskoj mehanici strukture prikazana na Četvrtoj internacionalnoj konferenciji računske tehnologije struktura (ovde CTS'98) avgusta 18 do 20, 1998 u Edinburgu su ovde opisana. Konferenciju je organizovala Civil-Comp. Press iz Edinburga. Oko 15 izabranih naučnika, istraživača i stručnjaka iz računske mehanike, kompjuterske nauke i srodnih oblasti prikazalo je svoja naučna dostignuća koja predstavljaju "poslednju reč" nauke u ovim oblastima.