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THEORETICAL and EXPERIMENTAL ASPECTS of CONTINUUM MECHANICS

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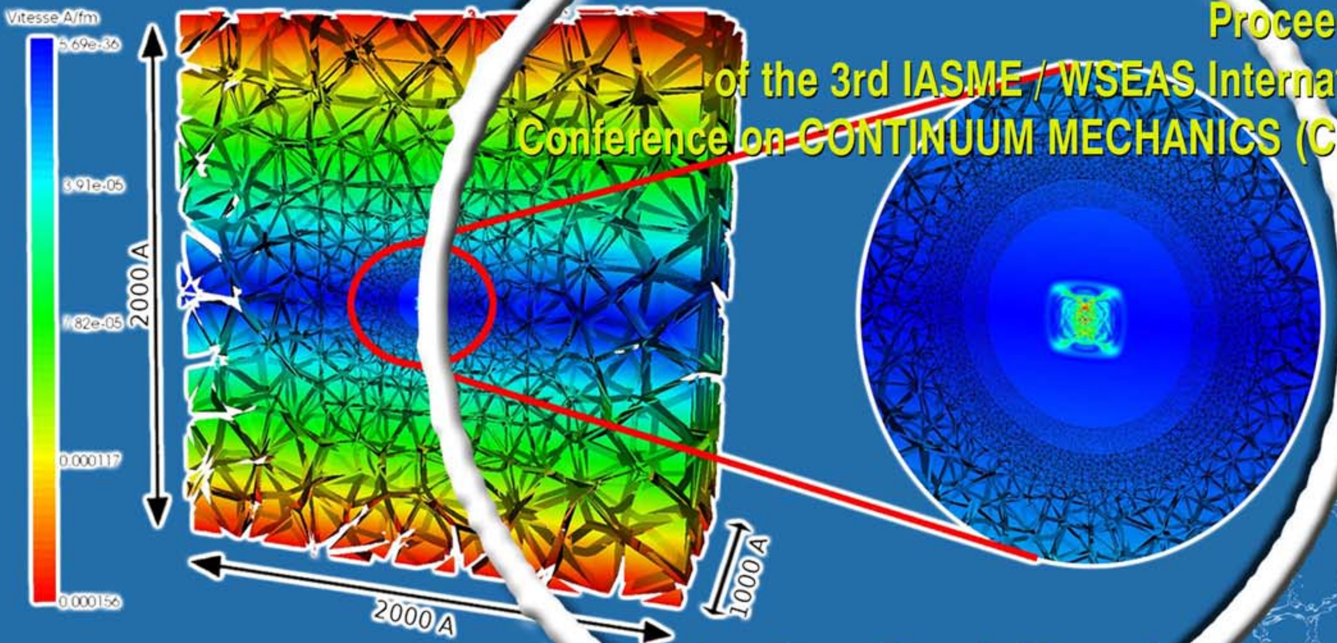

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Preface

This book contains proceedings of the 3rd IASME / WSEAS International Conference on CONTINUUM MECHANICS (CM'08) which was held in the University of Cambridge, UK, February 23 25, 2008. The WSEAS CONTINUUM MECHANICS (CM) Conference was held in Chalkida, Evia Island, Greece, May, 2006, in Slovenia, May, 2007, and this year, in the University of Cambridge, UK. The Society (WSEAS) has also organized many other separate or joint conferences on Fluid Dynamics, Aerodynamics, Heat and Mass Transfer, Environmental Engineering, Numerical Mathematics etc.... The relevant titles could be retrieved from the web site: www.worldses.org/history.htm

The 3rd IASME / WSEAS International Conference on CONTINUUM MECHANICS (CM'08) aims to disseminate the latest research and applications in the afore mentioned fields. The friendliness and openness of the WSEAS conferences, adds to their ability to grow by constantly attracting young researchers. The WSEAS Conferences attract a large number of well-established and leading researchers in various areas of Science and Engineering as you can see from **http://www.wseas.org/reports**. Your feedback encourages the society to go ahead as you can see in **http://www.worldses.org/feedback.htm**

The contents of this Book are also published in the CD-ROM Proceedings of the Conference. Both will be sent to the WSEAS collaborating indices after the conference: **www.worldses.org/indexes**

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Expanded and enhanced versions of papers published in these conference proceedings are also going to be considered for possible publication in one of the WSEAS journals that participate in the major International Scientific Indices (Elsevier, Scopus, EI, Compendex, INSPEC, CSA .... see: www.worldses.org/indexes) these papers must be of high-quality (break-through work) and a new round of a very strict review will follow. (No additional fee will be required for the publication of the extended version in a journal).

We cordially thank all the people of WSEAS for their efforts to maintain the high scientific level of conferences, proceedings and journals.

The Editors

Proceedings of the 3rd IASME / WSEAS International Conference on CONTINUUM MECHANICS (CM'08)

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Plenary Lecture I

Constitutive Modeling of Soft Biological Tissues: Some Problems and Advances in their Solution

Professor Mikhail Itskov
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Abstract: Soft biological tissues are complicated, highly functional natural structures. The distribution, arrangement and interaction of their constituents lead to a diversity of mechanical properties like e.g. strong anisotropy, highly non-linear behavior, the ability to undergo large elastic strains or deformation induced softening in the form of preconditioning. Facing this variety, development and application of constitutive models is not a trivial task and many methods successfully applied to engineering materials fail to describe biological tissues adequately.

Besides the requirements from a biological perspective, any appropriate constitutive model is expected to yield physically reasonable results. When mechanical boundary value problems are considered, the existence of a solution is desired. Thereby, the issue of material stability also plays an important role. For hyperelastic materials, both these conditions can be fulfilled if the strain energy function is polyconvex and coercive. We propose a generalized polyconvex anisotropic strain energy function represented by a series with an arbitrary number of terms. Each term of this series a priori satisfies the condition of the energy and stress free natural state. The collagen fiber alignment is taken into account by means of structural tensors, where orthotropic and transversely isotropic material symmetries appear as special cases. The model has successfully been applied to simulate rabbit skin, bovine pericardium, porcine myocardium, human aortic and other arterial tissues. For material characterization, biological tissues are usually tested in a preconditioned state. However, when living tissues are considered, the virgin response and preconditioning behavior itself can become crucial. For example, the mechanical behavior of human organs during surgery corresponds rather to a virgin than to a preconditioned state. The phenomenon of preconditioning is taken into account by an evolution of material parameters in the proposed hyperelastic model. The well-known Mullins effect can be obtained as a special case of this approach.

Plenary Lecture II

Multiphase Flow and Phase Transitions in Porous Media

Professor George G. Tsypkin
Institute for Problems in Mechanics
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Moscow, Russia

Abstract: The main objective of this paper is to present a number of the new mathematical models of the multiphase flow with phase transitions in porous media. The models were formulated as generalizations of the classical Stefan problem and are based upon fundamental conservation laws and relations of equilibrium thermodynamics. It was shown that phase transition moving boundary can be considered as a jump of saturation functions. This fact allowed apply the theory of discontinuity to obtain the boundary conditions at unknown moving boundaries for a wide class of various processes in porous media. The semi-analytical asymptotic method using both similarity solutions and numerical calculation was developed. This approach was applied to investigate the phase transitions problems in the fields of soil science (freezing, thawing and evaporation in soils), geothermal reservoir modeling and mathematical modeling of gas hydrate decomposition in gas fields and marine sediments.

Brief Biography of the Speaker: G. Tsypkin is a Senior Researcher in the Institute for Problems in Mechanics of Russian Academy of Sciences. He received the Ph.D and Doctor of Sciences degrees from the Institute in 1982 and 1995 respectively. His research interests include phase transitions in porous media, geothermal reservoir modeling, transport phenomena in soils (evaporation, freezing and thawing), gas hydrates formation and decomposition in gas fields and marine sediments, stability of interface in porous media. He has held several research grants from the Russian Fund for Basic Research, NATO, INTAS, CNR (Italy), Royal Society of London etc. He gave lectures as a full professor at the Moscow State Technical University n.a. N. E. Bauman and Yakutsk State University. G. Tsypkin has over 80 high impact publications and 2 books.

Plenary Lecture III

Energy Theorems in the Framework of the Strain Gradient Theories

Professor George I. Tsamasphyros
Faculty of Applied Mathematical and Physical Sciences
National Technical University of Athens
Greece

Abstract: The scope of the present work is to present Hu – Washizu & Hellinger-Reissner type energy functionals for various mixed formulations in the framework of the multidimensional linear Strain Gradient Theory developed by Mindlin & co-workers.

The main characteristic of the linear Strain Gradient theory is the consideration of the existence of microstructure in the material, which in turn gives rise to a great amount of new independent kinematic variables. These new variables lead to complicated forms of main boundary value problem. For example, it is easy to verify that the equilibrium equations are of the 4^{th} order with respect to the displacement field. Another, hindrance to the direct application of these theories is the fact that the complicated boundary conditions that appear in this framework are somewhat difficult to interpret physically. With the above in mind, various mixed formulations (of the Ciarlet-Raviart type) have been developed in order to incorporate combinations of variables that include, but do not limit to, the classic stress (τ) & strain (ε), displacement field (u), double stress (μ), relative stress (γ) and 1^{st} (θ) & 2^{nd} (k) gradient of the displacement field. For reasons of completeness the following mixed formulations are proposed 1) μ-τ-u 2) μ-u 3) μ-τ-k-ε-u 4) θ-u-γ.

It should be noted that in this case a direct extension to the classic Hu – Washizu & Hellinger-Reissner energy functionals (as they appear in the standard elasticity), cannot be made due to the great plethora of viable combinations among the classic and microstructural kinematic variables. However, as it is shown in the present work, similar energy functionals can be stated due to the fact that all of the above stated mixed formulations originate from the form $a(\underline{u},\underline{s}) = F(\underline{s})$ and that their solution minimizes the functional $I(\underline{z}) = (1/2)a(\underline{z},\underline{z}) - F(\underline{z})$.

Another implication of the current work is that it can be seen as a broad reference base for future numerical implementations of these theories by means of, for instance, various weighted residual methods such as the Standard Galerkin method.

Brief Biography of the Speaker: George I. Tsamasphyros is a Professor of Computational Mechanics at the Faculty of Applied Mathematical and Physical Sciences of the National Technical University of Athens (NTUA), Greece. He received the B.S. in Civil Engineering from the NTUA and his M.S in Applied Mathematics / Mechanics of Solids as well as the PhD degree (Doctor of Sciences) from the University of Paris VI.

He has supervised 14 PhD candidates and teaches several BA and MA courses. Dr G. Tsamasphyros is the author of over of 100 published papers in referee journals, 80 papers published in International Conferences and 12 books, all of them are used as textbooks in NTUA and other Greek Universities. He has been chairman of the Department of Mechanics, vice-dean of NTUA, Secretary of the Ministry of Education-Responsible of matters of the European Union.

His research interests are Computational Mechanics, (covering a wide spectrum of it: Finite Element Method, Integral Equations, Boundary Element Method, Integral Transformations, Finite Differences, and Finite Volumes). Special emphasis is given to finding new methods for calculating the error and the convergence of these methods. The boundary value problems which are confronted concern elasticity problems, fracture mechanics, as well as problems of gradient elasticity (materials with microstructure) and coupled fields – piezoelectric materials, composite materials, structure repair, wear and fatigue of materials, as well as biomechanics issues.

Another aspect of his research concerns the use of contemporary methods of sensing and measurement (optical - Bragg Gratings – Magnetic and Piezoelectric Sensors) for monitoring of structures emphasizing on the control of structural integrity by using neural networks.

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