DETALLE DE CONFERENCIAS PLENARIAS

CONFERENCIA PLENARIA: SERGIO IDELSOHN

MARTES 6/11 – 10:00 a 11:00

AUDITORIO

A PARTICLE-BASED METHOD FOR THE SOLUTION OF TURBULENT FLUID FLOWS

Sergio R. Idelsohn[a,b], Norberto M. Nigro[b], Axel Larreteguy[c], Juan M. Gimenez[b], and Pavel Ryzhakov[a]

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Keywords: DNS, Lagrangian formulations, multi-scale problems, homogenization.

Abstract. Although the Navier-Stokes equations are equivalently applicable to both laminar and turbulent fluid flows, the current computing power generally precludes employing fine meshes that would allow to simulate turbulent flows without introducing empirical approximations. The prediction power of the models is therefore restricted to problems within the margins of the selected empirical approximation. Solving a problem without such approximations on a mesh sufficiently fine so as to represent the whole expected range of eddy sizes is known as “Direct Numerical Simulation” (DNS). Taking into account that many fluid flow problems of industrial interest are indeed turbulent, it is worthwhile to continue improving the models so that they fit more and more with the physics of the problem. Simulating a CFD problem in a given domain with a “fine enough” DNS mesh introduces an unmanageable number of unknowns for current computers. The project we are working on involves modelling turbulent flow in a DNS fashion, i.e. without any additional turbulence model. However, we strive to develop an approach considerably more computationally efficient than a classical DNS. The basic idea is as follows. The total solution is splitted in two parts: a macro solution obtained on a coarse mesh, and a micro solution obtained on a fine mesh that can be subdivided into many equally shaped small domains, the so-called RVEs (for “Representative Volume Elements”). These RVEs, in principle, can be solved individually and independently from each other. The RVEs may even be previously solved off-line for different time-dependent loads. The micro and macro problems are coupled iteratively. Another important aspect of the solution is the use of a particle-based fluid formulation at the macro level to move the fine mesh. Then, the RVEs will take care not only of the transport of the velocity and pressure, but also of the transport of the micro-eddies that may appear in some RVEs, thus convecting the turbulent energy. This is a very important feature in turbulent flows where turbulence is produced in some high gradient regions and is then convected to other regions with different gradients. This new technique opens the door to the simulation of active fluids for which none of the current turbulent models would give acceptable results. This presentation is a work in progress, but the results obtained so far are encouraging.

CONFERENCIA PLENARIA: EDUARDUS KOENDERS
MARTES 6/11 – 16:50 a 17:50
AUDITORIO

RECENT DEVELOPMENTS IN MICRO-LEVEL MODELLING OF TRANSPORT AND STORAGE PHENOMENA IN COMPOSITE MATERIALS

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Keywords: Heat storage, composite materials, modelling, transport.

Abstract. In the last century, the use of concrete as a structural building material has grown towards vast quantities, while at the same time, the construction industry committed itself towards reducing its carbon footprint dramatically by turning its “grey” image into a “greener” and a more environmentally-friendly one. Significant efforts still have to be done in enhancing a concrete’s sustainability perspective by, for instance, increasing its efficiency in energy storage ability. Existing building stocks, as well as the majority of the newly established buildings and infrastructures, are largely made of concrete composites, which have the implicit ability to store and transport heat. Up till now, innovations in this particular field of building physics have been mainly focusing on improvements of the mechanical properties of construction materials in terms of durability and sustainability leading to systems with high performance, high strength or self-compacting properties, by applying ecological supplementary cementitious materials like fly-ash, lime stone, silica fume, clays, etc. Innovations are now asking for more progressive answers in terms of reusing construction demolishing waste, closed cycle materials systems, energy saving concepts, implicit heat storage concepts, etc. This trend has been pushed further by the construction materials research community, which turned their focus more towards the ability of cementitious systems to enhance their transport and storage ability. These developments made it possible to go even a step beyond these ambitions by turning cement-based materials into smart energy storing, balancing and/or reducing elements, via the integration of Phase Change Materials (PCMs) and possibly adding graphene to enhance its conductivity. Modelling these energy saving composite systems requires a multi-scale approach where the impact of phase change materials has to be considered at the micro-scale level and where its thermo-mechanical consequence acts at the meso- to macro-scale level. Recent developments also include ultra-light cementitious foams embedded with PCMs. These are ultra-low-density composites that combine an extremely low heat conductivity with the ability to store heat. These multi-functional materials can be modelled by applying a multi-scale and multi-physics approach while taking into account various coupling strategies. Computational methods enable the simulation and design of these smart composites that are eco-friendly and encompass an enhanced energy efficiency.

CONFERENCIA PLENARIA: PAUL STEINMANN
MIÉRCOLES 7/11 – 10:20 a 11:20
AUDITORIO

RECENT PROGRESS IN INVERSE FORM FINDING FOR METAL FORMING APPLICATIONS

Paul Steinmann, Philipp Landkammer and Michael Caspari

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Keywords: Form finding, sheet-bulk metal forming, optimisation, elasto-plasticity.

Abstract. Inverse form finding determines the optimal material configuration (i.e. the undeformed work-piece geometry) for a desired spatial configuration (i.e. the deformed work-piece geometry) for the case of prescribed boundary conditions. Previous approaches are either only available for two dimensional problems, computationally expensive, not applicable for path dependency or suffer from a cumbersome derivation. Hence, there is an urgent need for efficient and flexible approaches applicable to elasto-plastic materials and specially to forming processes. Here, we propose two different strategies to approach these difficulties. On the one hand, we focus on an algorithm based on an inverse mechanical formulation. It determines the sought material configuration e.g. for orthotropic elasto-plasticity at large deformations. Here we invoke a material modelling approach based on logarithmic strains for our investigations due to its modular formulation. Then the algorithmic procedure starts at the given spatial target configuration. We compute the sought material configuration by a parametrization of the deformation map in terms of spatial coordinates and a formulation based on inverse kinematics. We by-pass path dependency by alternating between a solution based on a direct and an inverse boundary value problem and mapping the computed plastic variables to the target configuration. For selected benchmark problems, this approach turns out to be more stable and efficient than traditional shape optimization methods. On the other hand, we present a novel, node-based and non-invasive optimization algorithm. Its derivation relies on gradient-based optimization theory and an analysis of the deformation stage. Therefore, the algorithm avoids a cumbersome derivation as needed for the inverse mechanical formulation. Furthermore, the advocated optimization approach is entirely independent from the constitutive modelling and straightforwardly applicable to frictional contact problems. We couple our algorithm non-invasively to arbitrary (also commercial) simulation environments. By applying a line-search strategy, testing the mesh quality and controlling inner nodal positions through an additional fictitious elastic problem, we enhance the stability of the algorithm. A convergence analysis of benchmark problems shows excellent results. Comparing both strategies indicates that the non-invasive optimization approach is better suited for an application to forming processes. In order to demonstrate its practicability, we apply the method to improve the results of sheet and sheet-bulk metal forming processes (cup deep drawing, local bulk forming operations with stamping of a sheet by tooth geometries, a combined process of drawing and upsetting). Furthermore, we verify the numerical results through forming experiments.

CONFERENCIA PLENARIA: FERRI ALIABADI
MIÉRCOLES 7/11 – 17:00 a 18:00
AUDITORIO

MESH REDUCTION METHODS FOR MULTISCALE MODELLING OF ADVANCED MATERIAL

Ferri M. H. Aliabadi

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Keywords: Boundary Element Method, Meshfree Element Free Galerkin, woven composite, polycrystalline materials.

Abstract. In these talk recent advances in mesh reduction methods, namely the Boundary Element Method and Meshfree Element Free Galerkin will be presented for modelling material degradation and failure through consideration of two material scales. It is generally recognized that macroscopic material properties depend on the features of the microstructure. The understanding of the links between microscopic and macroscopic material properties, main topic of Micromechanics, is of relevant technological interest, as it may enable deep understanding of the mechanisms governing materials degradation, damage characteristics and failure. In this talk damage initiation and failure in two very different types of material, that is polycrystalline and woven composite are discussed. Polycrystalline materials are used in many engineering applications. Their microstructure is determined by distribution, size, morphology, anisotropy and orientation of the crystals. The microscopic degradation is explicitly modelled by associating Representative Volume Elements (RVEs) to relevant points of the macro continuum, for representing the polycrystalline microstructure in the neighbourhood of the selected points. A grain-boundary formulation is used to simulate intergranular/transgranular degradation and failure in the microstructure, whose morphology is generated using the Voronoi tessellations. Intergranular/transgranular degradation and failure are modeled through cohesive and frictional contact laws. To couple the two scales, macro-strains are transferred to the RVEs as periodic boundary conditions, while overall macro-stresses are obtained as volume averages of the micro-stress field. Micromechanical approach for predicting the material properties and mechanical responses of woven composites is gaining popularity. In this approach, both normal and off-axis unit cell (UC) models are developed to describe the internal architectures of plain, twill and 3D woven composites with high fidelity. Material models are also selected or proposed to model the constitutive behaviours of the individual constituents. Specifically, a viscoplasticity model is selected to identify the nonlinear, rate-dependent response of the polymer matrix, and an improved Weibull function based formulation is proposed to characterize the anisotropic, post-failure behaviour of the fibre yarn material. Computational methods presented include the FEM and newly developed meshfree method. The analysis of a unit cell for 2D plain woven with two different geometries is discussed. The FEA of twill, satin and 3D woven composites are detailed. A newly more realistic mathematical representation of 2D and 3D woven composites is also reported. Finally, damage at the unit cell scale of plain woven composites using meshfree methods is examined in and multi-scale progressive failure analysis of plain woven composites using semi-analytical homogenisation with the FEM.

CONFERENCIA PLENARIA: ANNA PANDOLFI

JUEVES 8/11 – 10:15 a 11:15

AUDITORIO

ON THE RELEVANCE OF THE COLLAGEN ARCHITECTURE ON THE BIOMECHANICS OF THE HUMAN CORNEA

Anna Pandolfi

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Keywords: Biomechanics of the cornea, refractive power, patient-specific modeling, collagen microstructure, fiber-reinforced tissues, complex materials.

Abstract. Two recent studies concerning the biomechanics of the human cornea are illustrated in this talk. The focus is on the relevance of the fibrous collagen reinforcement on the mechanical performance of the tissue. The first study is based on an advanced finite element model describing the in-plane organization of the stromal collagen. The model includes recently discovered features of the collagen architecture, whose relevance on mechanics of the cornea has not been quantified yet. Numerical investigations analyze the response of the human cornea to three mechanical tests, i.e., the inflation, the probe indentation, and the dynamic air puff tests. Differences in the mechanical response are observed only in dynamic tests, while quasi-static tests are not able to differentiate between the models. The study concludes that from the mechanical point of view the actual detailed architecture of the collagen has a minor relevance with respect to the main anisotropic orthogonal collagen structure that has been considered and acknowledged in the literature. The second study is a simplified micromechanical model of the collagen fibrils that accounts for crosslink bonds always disregarded in numerical simulation given their complexity. The reinforcing structure is modeled with two sets of parallel fibrils, connected by transversal bonds within the single fibril family (inter-crosslink) and across the two families (intra-crosslink). The particular design chosen for this ideal structure relies on the fact that its ability to sustain loads depends on the degree of the crosslink and, therefore, on the bond density and stiffness. The mechanical response of the system is analyzed according to the level of interlacing and of the bond stiffness. The weakening of transversal bonds is associated to a marked increase of the deformability of the system. In particular, the localized deterioration of transversal bonds due to mechanical, chemical, or enzymatic reasons can justify the weakening of the stromal tissue resulting in localized thinning and bulging typically observed in keratoconus.

CONFERENCIA PLENARIA: RAINALD LOHNER

JUEVES 8/11 – 17:00 a 18:00

AUDITORIO

FROM COMPUTATIONAL MECHANICS TO CLINICALLY RELEVANT HAEMODYNAMICS: REQUIREMENTS, CURRENT STATUS AND OUTLOOK

Rainald Lohner, Juan Cebral and Fernando Mut

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Keywords: Computational Haemodynamics, CFD, Patient-Specific Computing, Biomedical Engineering, Data Bases, High Performance Computing.

Abstract. The late 1990's saw the first demonstration cases for computational haemodynamics. The last two decades have seen remarkable progress in this field, improving automation and accuracy for patient-specific geometry and boundary conditions, exploring fluid-structure interaction, developing models for thrombosis and haemolysis, as well as many clinically relevant diagnostics. Doing computational mechanics simulations for either basic understanding or design of devices has become commonplace, with many open-source, academic and commercial vendor options/examples. Still, the main question as to the clinical relevance of the physics being modeled and computed remains open. In order to sort with some degree of certainty the many theories as to what is important or not (high or low shear stress, complexity of flows, geometry of aneurysms, etc.), the classic medical approach has been human trials. This implies following many (possibly thousands) of patients over time. In order to test a new theory, or to measure a new quantity deemed as important, one must be able to access and re-run this patient-specific database at any given time. As the number of patients may grow into the tens of thousands, every step of the simulation and evaluation pipeline must be completely automated. The presentation will discuss the requirements in general terms and show an example for a haemodynamic database of the kind envisioned before that now exceeds 2,200 patient-specific cases and is used for virtual clinical trials.

CONFERENCIA PLENARIA: ARETI PAPASTAVROU

VIERNES 9/11 – 9:30 a 10:30

AUDITORIO

COMPUTATIONAL BONE REMODELLING REVISITED

Areti Papastavrou[a,b], Kefu Deng[b] and Paul Steinmann[b]

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Keywords: Bone Remodelling, Finite Element Method, Computational Biomechanics.

Abstract. Bone as a living material is able to adapt to loading by changing its density and trabeculae architecture. This process is referred to as remodelling. In this talk, a computational model that accounts for bone remodelling is presented, whereby novelties from the viewpoint of biomechanical modelling are the incorporation of material uncertainties, life-time aging and availability of nutritive substances. The physical process of remodelling is modelled using continuum scale, open system thermodynamics whereby the density of bone evolves isotropically in response to the loading it experiences. The fullynonlinear continuum theory is approximately solved using the finite element method. It is validated using a series of benchmark problems.

DETALLE DE KEYNOTE LECTURES

KEYNOTE LECTURE: PETER HAGEDORN

MIÉRCOLES 8/11 – 18:00 a 18:40

Aula 12

ONE ALONE MAKES NO COUPLING

Roberta Lima[a] , Rubens Sampaio[a] and Peter Hagedorn[b]

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Keywords: Electromechanical systems, coupled systems, parametric excitation, nonlinear dynamics.

Abstract. Electromechanical systems deal with the mutual interaction between electromagnetic and mechanical parts. In this paper, it simply means the connection of a DC motor and a mechanical part by some mechanism. This interaction is called coupling. The mechanical and the electromagnetic subsystems interact. To properly represent the dynamics of a coupled system, it is necessary to properly characterize this interaction between the parts. Any change in the modeling of the interaction affects the behavior of the entire system. Typically, the coupling between electromagnetic and mechanical parts is expressed by a set of coupled differential equations. The dynamics of the coupled system is given by an initial value problem comprising this set of coupled differential equations. In this paper, we discuss three mistakes found in the literature on electromechanical systems. The three mistakes somehow decouple the system. They maim the initial value problem of the coupled system, in a way that it looses one differential equation and the initial condition related to the lost equation. The remaining equations represent only the dynamics of the mechanical part. The dynamics of the motor is ignored in a way that the electromagnetic part is decoupled from the system. Apparently they are useful hypotheses, since they simplify the problem greatly. However they lead to wrong results, as is shown in this paper. To exemplify how the hypotheses mislead and change the dynamics, numerical simulations are performed for an simple electromechanical system. Observing the results, one sees, immediately, the inadequacy of them. The oldest of these misleading hypotheses was first made at least 75 years ago still persist in the literature. It seems that lately these hypotheses are used more than ever.

KEYNOTE LECTURE: JAN ČERVENKA
JUEVES 8/11 – 11:15 a 11:55
AUDITORIO

MODELLING SOFTENING MATERIALS IN ENGINEERING PRACTICE USING FEM AND CRACK BAND METHOD

Jan Cervenka[a] **, V. Cervenka**[a] **and S. Laserna**[b]

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Keywords: Finite Element Method, Reinforced Concrete, Crack band Method, Fracture Mechanics.

Abstract. When finite element nonlinear analysis is applied to address the typical engineering problems such as ultimate load carrying capacity or serviceability limits such as deflections or crack width, a special care should be taken for the proper definition of the crack band namely in the presence of reinforcement. The pioneering work of Bažant and Oh (Materials and Structures, RILEM 16 (3): 155–177, (1983)) introduced the crack band approach to address the issue of proper energy dissipation in nonlinear finite element analysis of brittle materials such as for instance concrete. The method has become a standard approach in most commercial as well as scientific programs for advanced finite element modeling of concrete and reinforced concrete structures. Engineers often apply nonlinear analysis with crack band approach to solve practical engineering problems. This rapid development is also embraced by the development of new national and international design standards. For instance model fib Model Code 2010 introduced for the first time a comprehensive system for the treatment of safety and model uncertainty for structural assessment and design based on nonlinear analysis. The paper attempts to provide a comprehensive treatment of the problem, when very large or very small finite elements are used in nonlinear simulations of reinforced concrete structure based on smeared crack models and crack band method as described in more detail in Červenka and Papanikolaou (Int Journal of Plasticity, 24(2): 192-220 (2008)). The paper proposes three localization limiters for practical applications of nonlinear finite element model using the smeared crack approach and crack band method both for tension and compression. The application of these localization limiters is demonstrated and verified on several problems ranging from shear failure, bending behavior and compressive failure. It is demonstrated that the simple application of these limiters can increase the accuracy of finite element analysis even if very small or very large finite element sizes are used, which is often necessity in practice or research and development.