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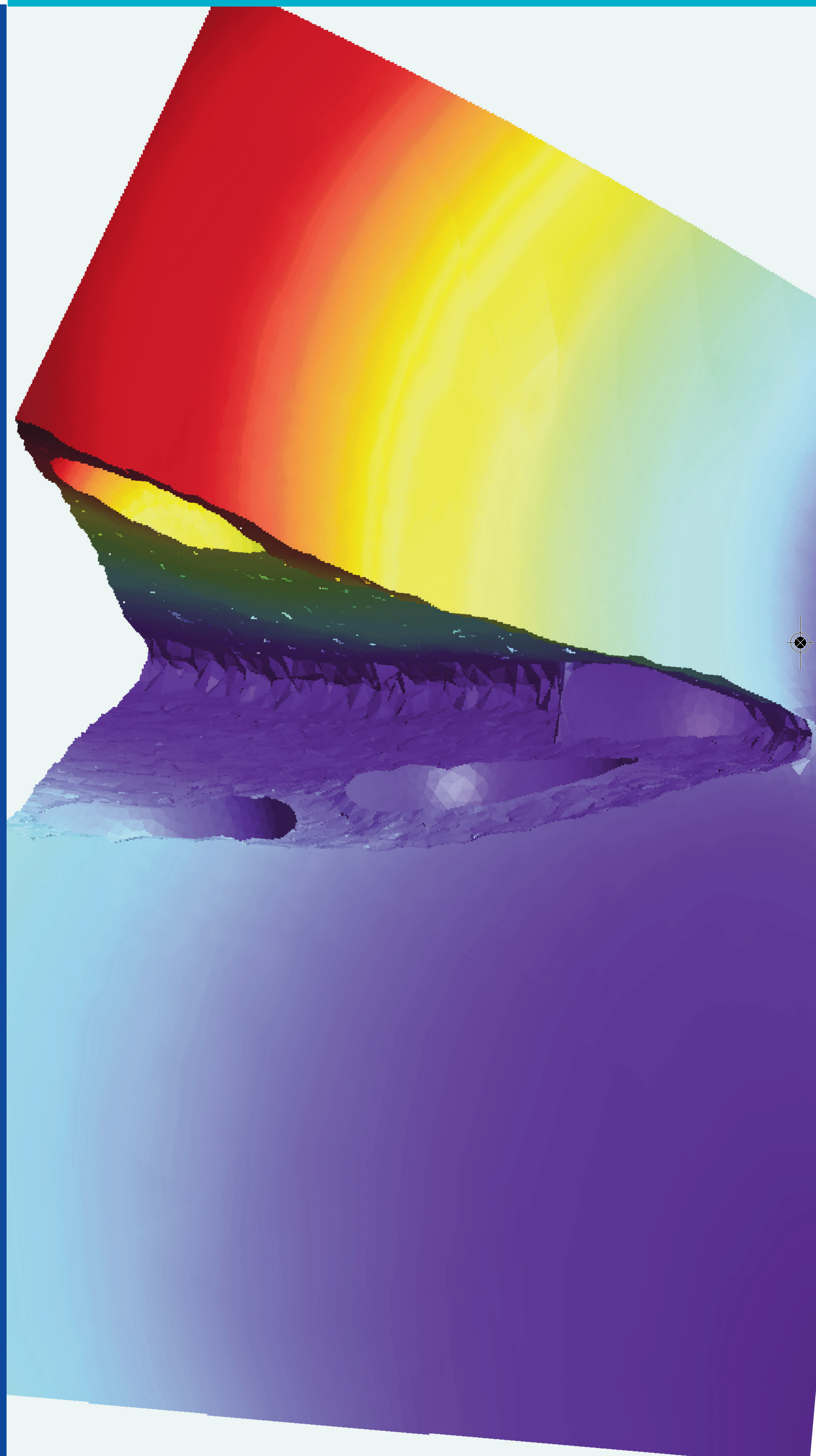

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contents

editorial

The search for new materials with enhanced functional capabilities regarding their strength, thermal, acoustic, permeability and electromagnetic features, among others, is a priority in many areas in engineering and applied sciences. Clearly the objects, structural components and devices of the future will be most probably formed by parts containing these new materials that will boost their mechanical behavior and their environmental and energy efficiency capabilities, as well as their capacity to act as active elements helping to improve the performance of the construction, vehicle or apparatus in which they are integrated.

Examples of applications of the new materials are insulation panels, heat retaining components, solar energy capturing elements and walls, active devices in the mechanical and bio-medical field, hydrophobic/hydrophilic surfaces, as well as structural components with increased resistance coupled to new functional capabilities, among others.

A possibility for developing new materials is the modification of those found in nature, via mixtures or other techniques used in composite material technology. A new trend is however emerging. This is the possibility to find the composition of new functional materials in a "virtual laboratory" using a combination of mathematical modeling, material science, optimization and predictive tools based on computational mechanics procedures. The properties of the new materials will be assessed via numerical experiments. The outcome of the design process will be one or several configurations of the material components and structure that fit best to the functional objectives targeted.

The manufacturing of parts with these new materials will be possible with the help of the new additive manufacturing techniques, also known as 3D printing. In occasions, samples of the material itself will be printed and then used to form specific components. In other occasions, a functional part will be directly printed incorporating the constituents and structure of the new material. This is not so futuristic as it might seem, if we take a look to the fast advances in material design and 3D printing technology. As an example see the article on material design via topology optimization in the pages of this issue of Expressions.

The possibilities that the design and manufacturing of new functional materials open for the computational mechanics community are enormous. New mathematical and numerical models will be required for describing the functional features of the materials, as well as for reproducing the complex manufacturing process. Here the use of multiscale analysis techniques for multi-physics problems will be mandatory. Also new computational methods will be needed that will allow material designers and engineers for dealing with large scale optimization problems and huge data sets in affordable computing times.

The health of the computational mechanics community is excellent as evidenced by the many scientific and technical events related to Computational Mechanics held over the world in 2017. Some 45 international conferences will take place in the five continents under the initiative of the IACM via its regional associations. We highlight the over 30 Thematic Conferences promoted by the European Community for Computational Methods in Applied Sciences (ECCOMAS). These conferences cover a wide range of topics in different fields of the engineering sciences and their applications. It is encouraging the many young investigators attending these events. I also highlight the increasing number of female researchers on computational mechanics, an activity that is fostered by the recently created IACM Female Researchers Chapter https://frciacm.wordpress.com/.

On the other hand, the XII and XIV edition of the world congresses of the IACM will be respectively held in New York and Paris on 2018 and 2020. The large and small events promoted by the IACM will be unique occasions for meeting and interacting with colleagues from other world regions. I hope you will be able to join us in some of these events.

Eugenio Oñate
Editor of IACM Expressions

Damage Mechanics from a Configurational Perspective : the Thick Level Set approach to Fracture

by
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Damage mechanics may be modeled from a configurational rather than a classical point of view. We first recall the general concept of configurational mechanics and then develop the way we use it through the Thick Level Set (TLS) approach for damage modeling and its transition to fracture.

Classical vs configurational mechanics

Configurational mechanics is unfortunately intimidating to many mainly because of a lack of teaching at universities. Several important books exist on the topic among which the ones by Gurtin (2000), Kienzler et al. (2000), Steinmann et al. (2005) and Maugin (2011) [3, 4, 5, 6]. We stress here the importance of configurational mechanics as a powerful tool to model constitutive material relations.

To do so, we go back to basics: a mechanical model is built out of three main ingredients.

Figure 1:
Classical (left) and configurational (right) ingredients to model crack growth. Crack opening velocity and cohesive tractions for the cohesive zone model (left) and crack tip speed $\dot{a}$ and energy release rate G for the configurational approach (right)

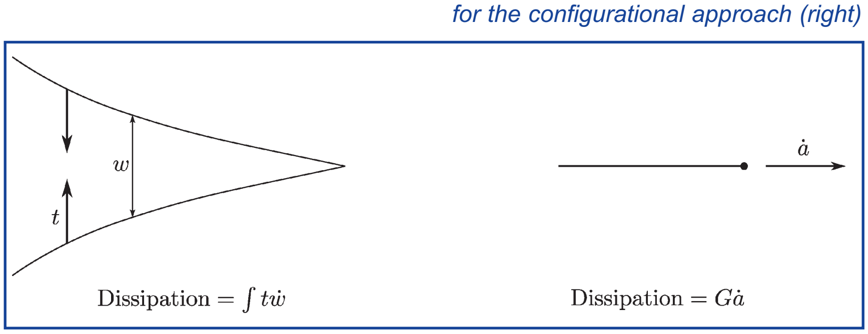
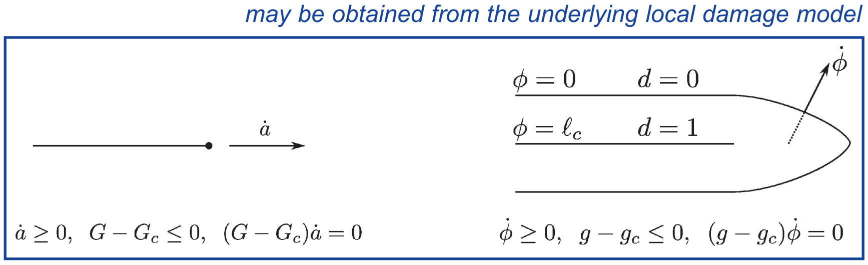


Figure 2:
Configurational approaches to fracture. The Griffith model (a) and the Thick Level Set model (b). The local energy release rate g and its critical value gc may be obtained from the underlying local damage model



First, one describes how the matter is allowed to move, this is the kinematics description. Different assumptions are possible among which one classically has: rigid bodies, first gradient theory, higher-order (second gradient, Cosserat, micro-polar, …) , shell theory (bernouilli, Kirchhoff, …). Second comes the balance laws : mass (conservation), linear and angular momentum, energy and entropy (imbalance). Linear and angular momentum balance laws exhibit the proper "stress" quantities to be used in the model. The stress description is in fact a direct consequence of the kinematics description (for rigid bodies, only resulting force and moment will appear whereas for shell a more complex description comes in). Fortunately, kinematics description and balance laws do not constitute in general a complete set of mathematical equations otherwise the world would be quite dull. In order to close the set of equations one needs a constitutive model. The constitutive model links the kinematics and stress description.

As an example of model, consider the one needed for the stress analysis in pipes. First, one states that deformation will be very small and thus the infinitesimal strain tensor may be used. Then, balance laws bring the equilibrium equations. Finally, Hooke elastic model closes the system.

Suppose now that a crack is present in the pipe and propagates, how is the model affected? Two point of views are possible. The first one (cohesive zone model) proceeds from classical mechanics. It assumes that some "glue" ahead of crack tip ties firmly together both sides of the crack. For some critical tension in the glue it degrades and the crack opens and progresses. As the crack propagates, the system dissipates energy because the velocity at which material particles on each side of the crack separates is opposite to the forces still retaining the two sides of the crack *(figure 1)*. The alternative point of view, proceeds from configurational mechanics. The kinematic descriptors in the model are enriched by the crack tip velocity. This velocity is not classical/material since not attached to a given particle, it is called a configurational velocity. Even though the crack tip velocity is not a material velocity if yields dissipation. So, by computing the dissipation and dividing by the tip velocity, one can find the force acting on the tip to create the dissipation (for obvious reason this force is usually called energy release rate). This force is called configurational force because it is of different nature than a classical force *(figure 1)*. Once this force is defined, one can build a constitutive model relating the force to the velocity, the most famous being Griffith model which introduces a critical energy release rate for crack advance *(figure 2 left)*.

The two constitutive modeling points of view are thus very different. However, it is well known that if the critical energy release rate is taken as the area under the tension separation curve of the cohesive model, both point of view will give the same dissipation for an auto-similar cohesive zone translation.

Cohesive and Griffith models have some limitations. Basic cohesive models cannot for instance model splitting crack because they do not sense in-plane strain and Griffith model cannot represent correctly size effect because it lacks a length scale. A more general (but more complicate) approach is to consider a degradation process in the bulk (and not just on an interface as in the CZM). An elasto-damage bulk model if for example well suited for quasi-brittle media such as concrete.

An elasto-damage model suffers from two issues. First, it is ill-posed since dissipation may be located on a zero measure area. Second, the exact crack location is not known, one only has access to a diffuse damage zone (with the consequence that infinite strains need to be handled over long distances where the material is fully damaged).

To solve the first issue, a length must be introduced to force damage to localize over some thickness. Approaches vary in the way the length is introduced. It can be in an integral manner (averaging of the local damage driving force over a disk of some length) or a gradient manner (the damage gradient enters on top of the damage itself as internal variable, similarly the strain gradient may also be introduced on top of the strain as an extra kinematic variable). A comparison between non-local and gradient-enhanced approaches mays be found in [2]. For dynamics, so called delayed damage models introduce implicitly a length through the ratio of the elastic wave speed and the maximum damage rate [1].

Before moving to the Thick Level Set approach, we note that elasto-damage models and their regularization by a length proceed from a purely classical approach and do not include any configurational aspects. As a consequence, the notion of moving discontinuities (ie cracks) is not in the genes of these models.

The Thick Level Set damage model

The TLS resolves the above mentioned issues (lack of a length in local softening models and desire to exhibit displacement jumps inside localizing zones) by introducing a configurational twist in the classical local damage models [7, 8]. The idea is to consider that damage is organized inside a moving front separating the damaged and undamaged zone. Damage is then given as an explicit function of the distance to the front. This a bit similar to a crack tip description except that with the crack tip one considers that the material point is completely degraded as soon as it is touched by the crack tip. Here we consider that the degradation is not immediate but will need some distance lc for the material to be completely degraded *(see figure 2, right and a typical damage profile figure 3)*. Damage evolution is completely tied to the front evolution. Displacement discontinuity is allowed on the set of point for which damage is 1 (ie level set lc). In Griffith model, the crack speed is related to the energy release rate at the crack tip. Similarly in the TLS model, the front speed (at every point of the front) is related to the energy release rate at every point on the front (also called configurational forces).

"... these computational assets are important as we move towards industry type application."

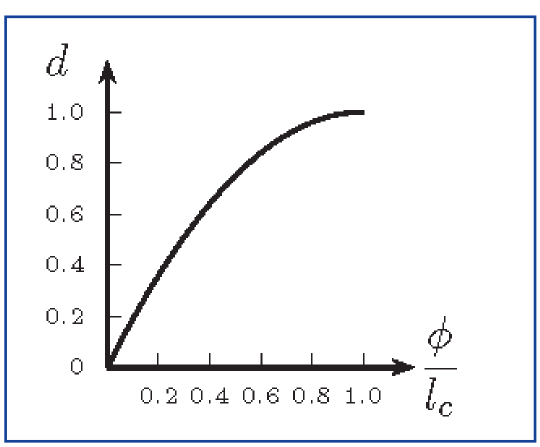


Figure 3:
A typical damage profile used in the TLS

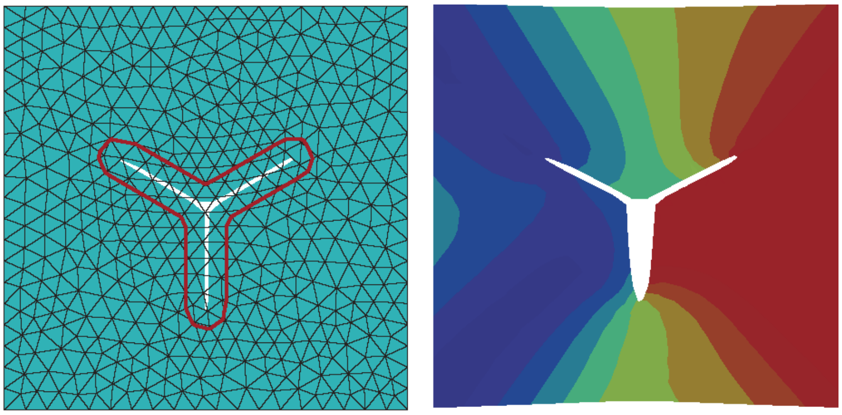
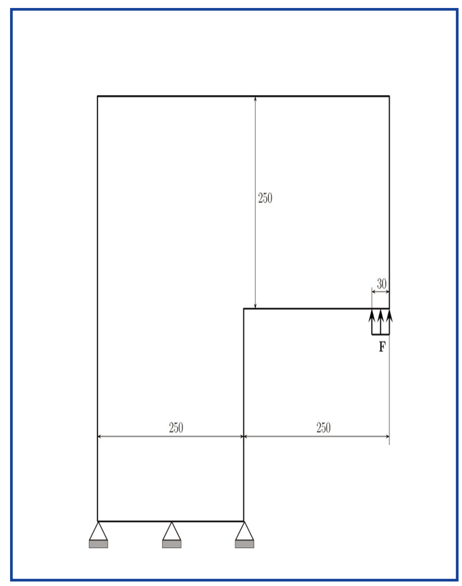


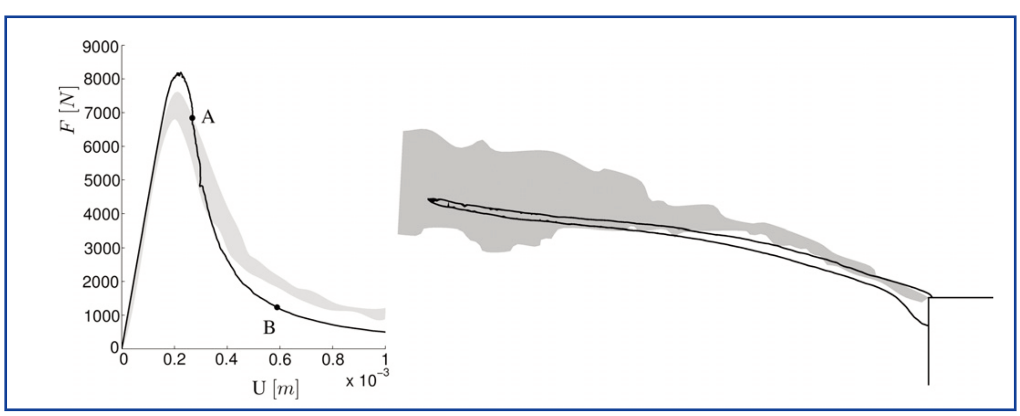
Figure 4: *Capability of the extended finite element method to model complex displacements jumps (right) on locations indicated by the iso-lc level set of the TLS (left)*

The implementation of the TLS relies on the use and update of a level set field (distance function to the damage front). Also, the eXtended Finite Element (X-FEM) approach is used to insert displacement discontinuities along the crack path located by the level set lc [9]. An example of discontinuous displacement field modeled with the X-FEM inside a TLS damage zone is shown in *figure 4*. For quasi-static analysis, a dissipation control is adopted, the loading intensity is thus an outcome of the simulation. Regarding the computational performance of the approach it should be noted that the damage update does not require solving a global partial differential equation but only a local one in the damaged zone. Even in this zone, it is possible to avoid completely any matrix solve. This is particularly interesting in explicit dynamics where the displacement field does not require matrix solve as well.

Applications

The TLS has been applied to solve 2D and 3D problems of quasi-brittle fracture in quasi-static. *Figure 5* depicts the case the failure of a L-shape panel. The L-shape panel has also been analyzed in 3D under shear and the crack opening at some point in the loading is given in *figure 6*. Note that the TLS handles crack initiation automatically.





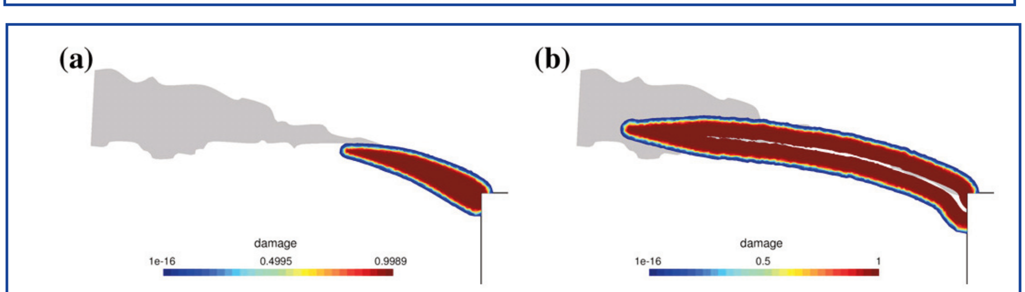


Figure 5: *Failure of an L-shape panel: geometry of the specimen (dimensions in mm), force-displacement curve and crack path obtained with the TLS (experimental envelope in gray), damage field at two different instants (A and B).*

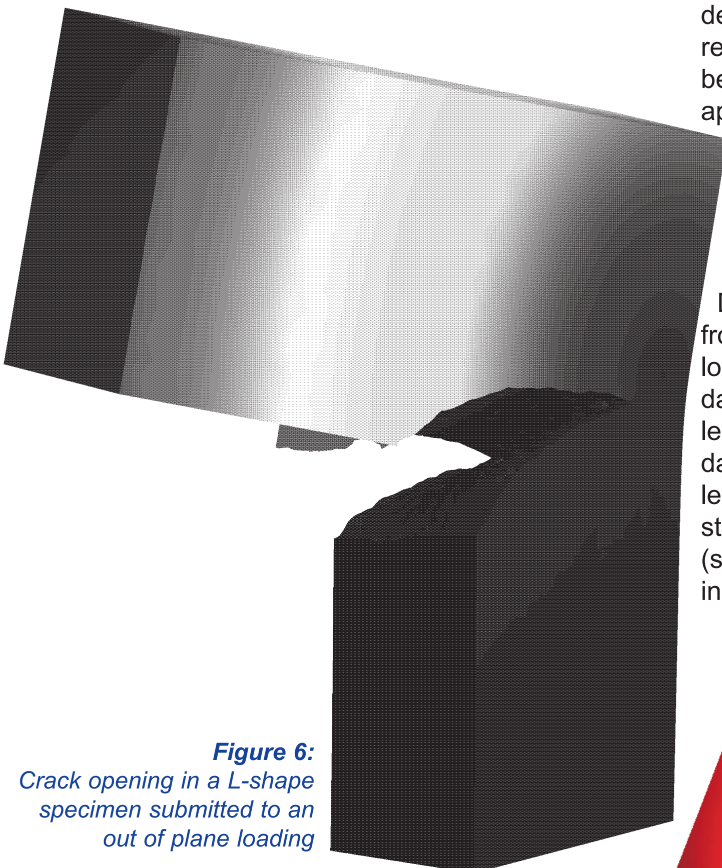


Figure 6:
Crack opening in a L-shape specimen submitted to an out of plane loading

Figure 7 and 8 depicts the example for the progressive fracturing of a cube with voids [16].

For composites, transverse cracking [12] as well as mode II type delamination [15] were considered. TLS has also been used with explicit dynamics for crack branching [14] or fragmentation [18].

Further informations

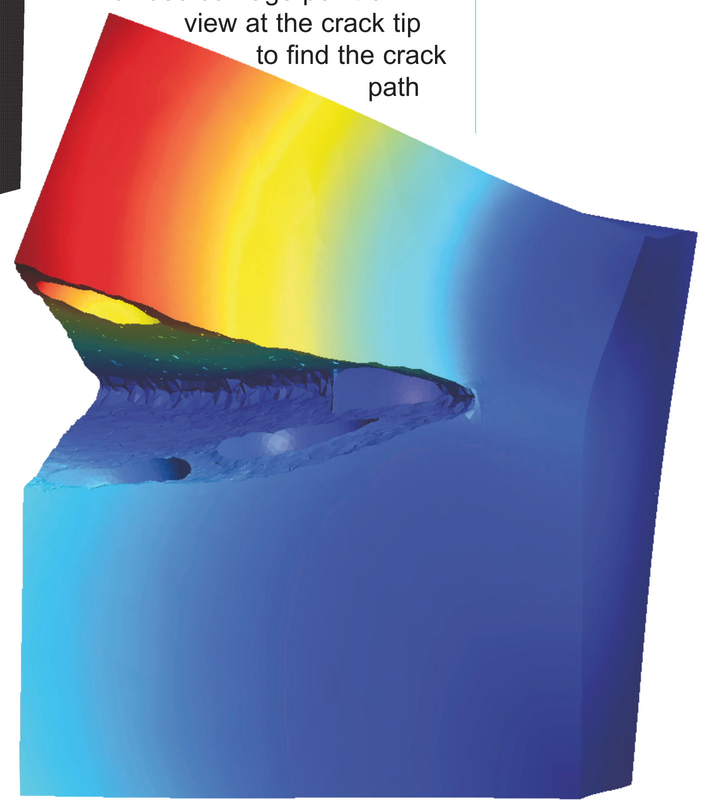
The TLS model detailed above considers that damage yields immediate softening of the material. If it is not the case (damage hardening), one still considers a zone where damage evolves in a configurational (non-local) manner. The remaining part of the structure undergoes classical local damage evolution [10]. The boundary between the non-local and local damage zone moves in order to preserve damage continuity.

Another point of view on the TLS may be found in [17]. In this paper, the constraint on the damage gradient is introduced in the free energy and enforced in the variational principle through a Lagrange multiplier.

The moving damage zone in the TLS mimics a cohesive zone. In the paper [11] the proper choice of the TLS parameter to represent a given cohesive model is detailed. Finally, interested readers may found a comparison between the TLS and phase-field approaches in [13].

Conclusions

The Thick Level Set approach proceeds from a configurational point of view. Damage evolves following a front located by a level set. The location of the crack inside the damage zone is also given by a level set which is an offset of the damage front by a characteristic length. The TLS can be seen as strong discontinuity approach (since displacement jumps are introduced) while retaining a diffuse damage point of view at the crack tip to find the crack path



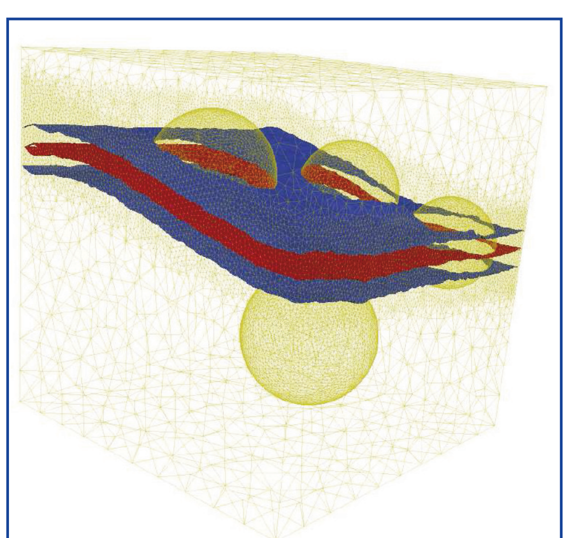


Figure 7:
Crack opening in the cube at an intermediate stage (above) and final crack location (left)

The crack is located by the red surface whereas damage has extended in between the two blue surfaces

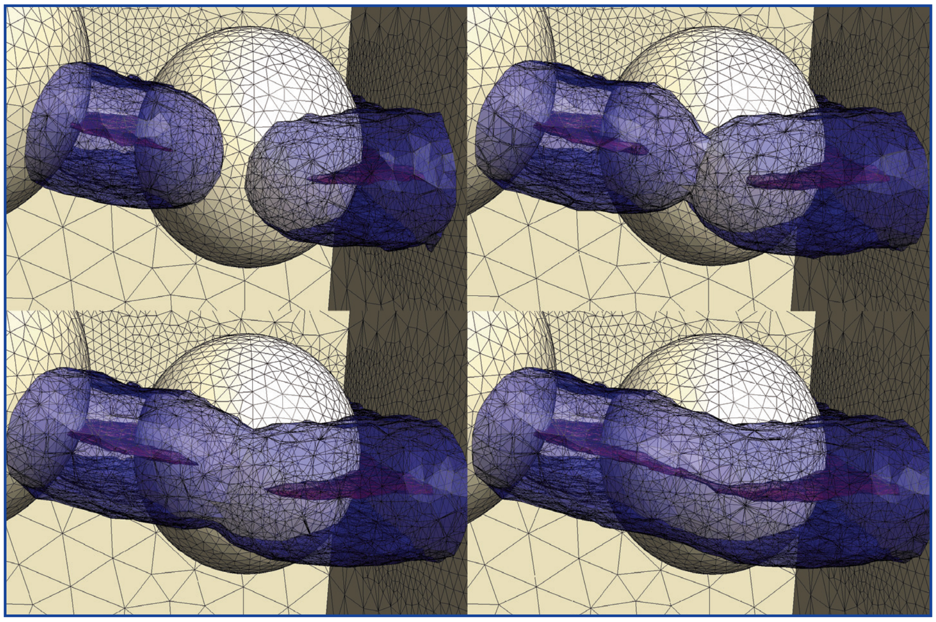


Figure 8:
Details on the cube related to the automatic merging of the damage zones followed by the automatic merging of the cracks around a void

and to have automatic nucleation and merging of cracks. Regarding computational performances, the TLS does not require matrix solve for the damage update. Also, as soon as displacement discontinuity is placed with the X-FEM, the mesh may be coarsened. The need for mesh refinements is thus limited to the active tips/fronts of the cracks. We believe that these computational assets are important as we move towards industry type applications.

Acknowledgements

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Level Set-Based Topology Optimization and its Application to Device and Material Design

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Topology optimization in now one of the mainstreams in the field of structural optimization is widely utilized in many industries, and a variety of new topology optimization methods has been recently proposed. In this article, we present a method in which boundary expressions are used in a piecewise constant type of level set function and highlight its application in innovative structural design problems.

Introduction

Topology optimization [1] is the most flexible type of structural optimization because topological changes as well as shape changes are allowed, and it provides high performance structures and has the potential to implement new structural functions. Typical topology optimization methods include homogenized design methods [2] and density approaches, such as the Solid Isotropic Material with Penalization (SIMP) method [3]. These methods have been applied to a variety of physics problems such as structural mechanics, thermal diffusion [4], fluid mechanics [5], and electromagnetics [6], and are widely utilized in many industries such as automotive and aerospace engineering. In this article, we introduce a different type of topology optimization method that represents the boundaries of a target structure using a piecewise constant type of level set function [7], offer design examples for mechanical structures considering geometric constraints, and introduce applications for the design of devices and materials in an acoustic-elastic coupled system.

Level set-based topology optimization

Our research group developed a different type of topology optimization method where a piecewise constant type of level set function is introduced for the boundary expressions, as shown in *Figure 1*. The optimization problem is regularized using Tikhonov regularization and design variables are updated based on a reaction-diffusion equation that provides quick convergence. Our method can qualitatively specify the geometrical complexity of the optimal configurations by appropriately setting a regularization parameter that changes the intensity of the Tikhonov regularization effect. This qualitative specification of the geometrical complexity allows geometrical constraints related to the manufacturability of the optimal structures to be taken into account. Our research group is now developing a conceptual design system implemented in mid-range CAD software that automatically provides CAD models based on optimal configurations obtained by our developed topology optimization method, under the support of the Strategic Innovation Promotion Program (SIP), a Japanese national project.

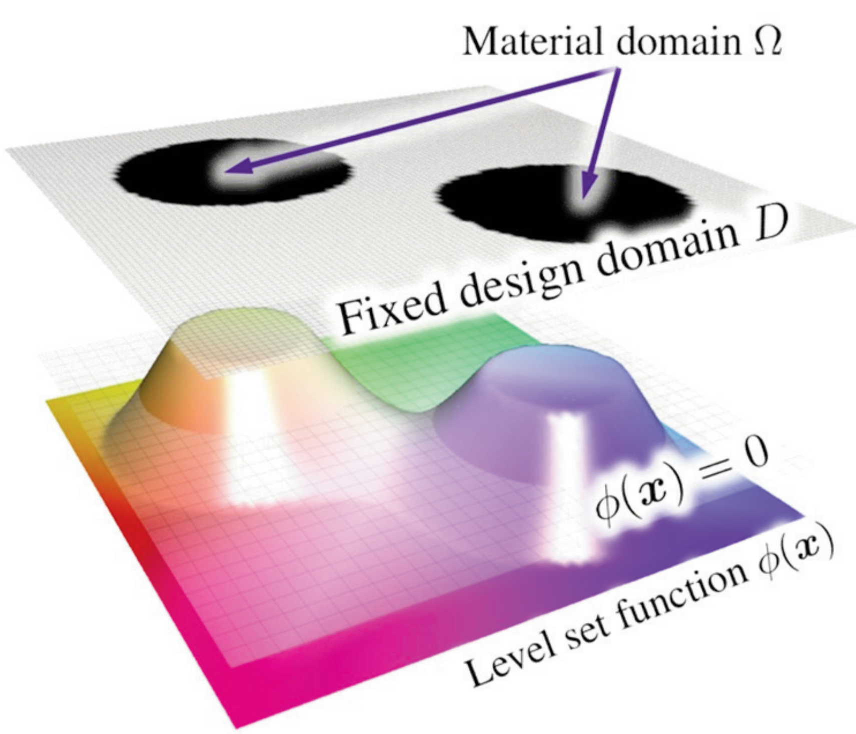
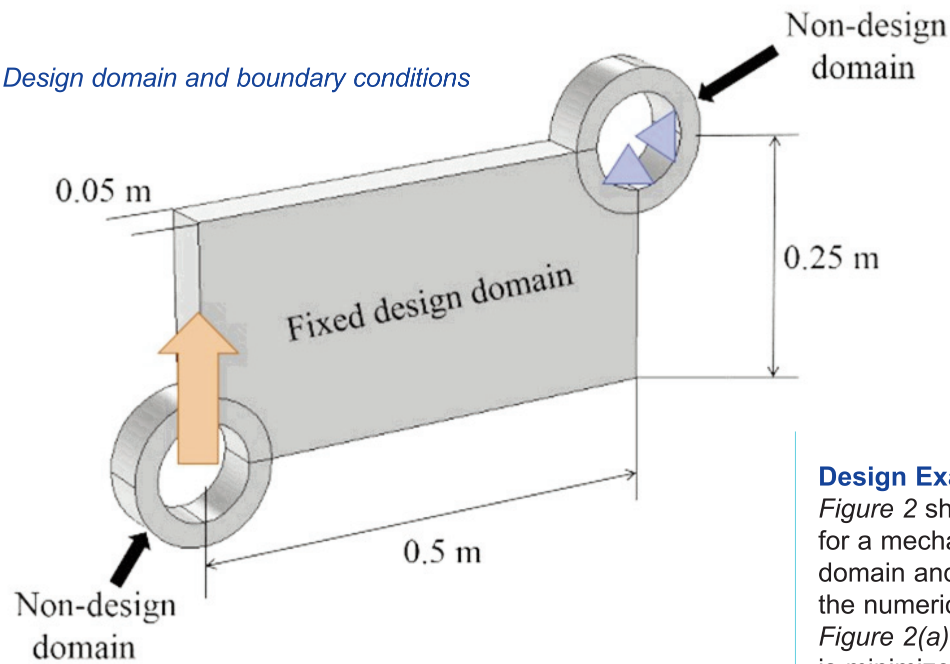


Figure 1:
Boundary expression using a piecewise constant type of level set function in 2 dimensions

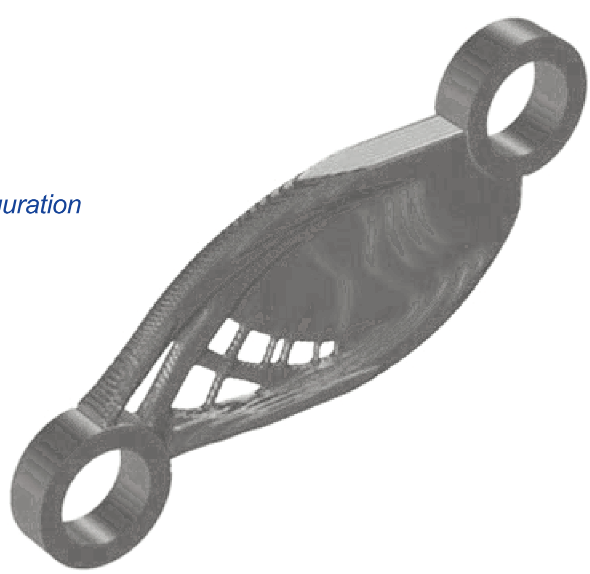
Figure 2:
Simple design example for a mechanical part

(a) *Design domain and boundary conditions*



(b) *Optimal configuration*
τ= 1.1 X 10 $^{-4}$

(c) *Optimal configuration*
τ= 1.1 X 10 $^{-5}$



Design Examples

Figure 2 shows a simple design example for a mechanical part, with the design domain and boundary conditions for the numerical analysis illustrated in *Figure 2(a)*. Here, the mean compliance is minimized under a volume constraint. *Figures 2(b) and (c)* show optimal configurations obtained with two different regularization parameter values. The optimal configuration in (b), with the greater value, is geometrically simpler although the mean compliance is larger.

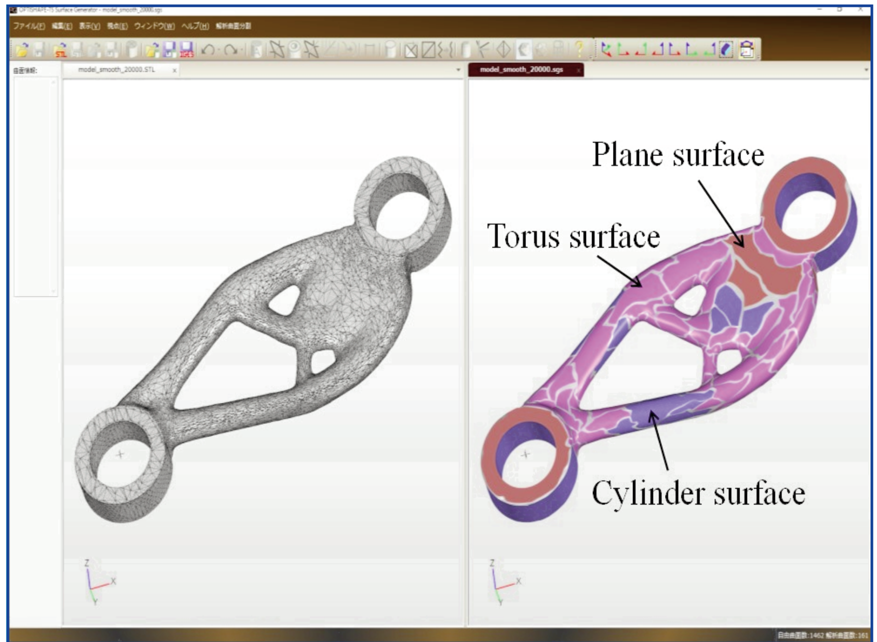
Figure 3 shows the CAD model construction process in the conceptual design system developed by the Quint Corporation. To meet the needs of small to medium-sized enterprises, our system advantageously assembles CAD models that are essentially composed of analytical surfaces such as planes, tori, and cylindrical surfaces.

Our proposed method can take into account more sophisticated manufacturing constraints by implementing additional advection-diffusion equations as constraints [8]. *Figure 4* shows a design example considering molding constraints.

Figure 4(a) shows a typical undercut geometry that prevents mold parts from being separated at the given parting line in the given parting direction. Our method can implement geometrical requirements for molding processes to ensure that undercuts and interior voids are avoided.

Figure 4(b) shows a conceptual scheme for a fictitious physical model described by a steady-state anisotropic advection-diffusion equation. In the fictitious physical model, material domains are represented as virtual heat sources and

Figure 3:
CAD model construction process in conceptual design system



the advection direction is aligned with a given parting direction. Void regions, where the value of the fictitious physical field is high, then represent either undercut geometries or interior voids, enabling the imposition of a molding constraint in the optimization procedure via the fictitious physical field. *Figure 4(c)* shows the fixed design domain and boundary conditions for a numerical example and four prescribed parting directions are shown in *Figure 4(d). Figure 4(e)* shows the obtained optimal configuration that is manufacturable using a four-part mold.

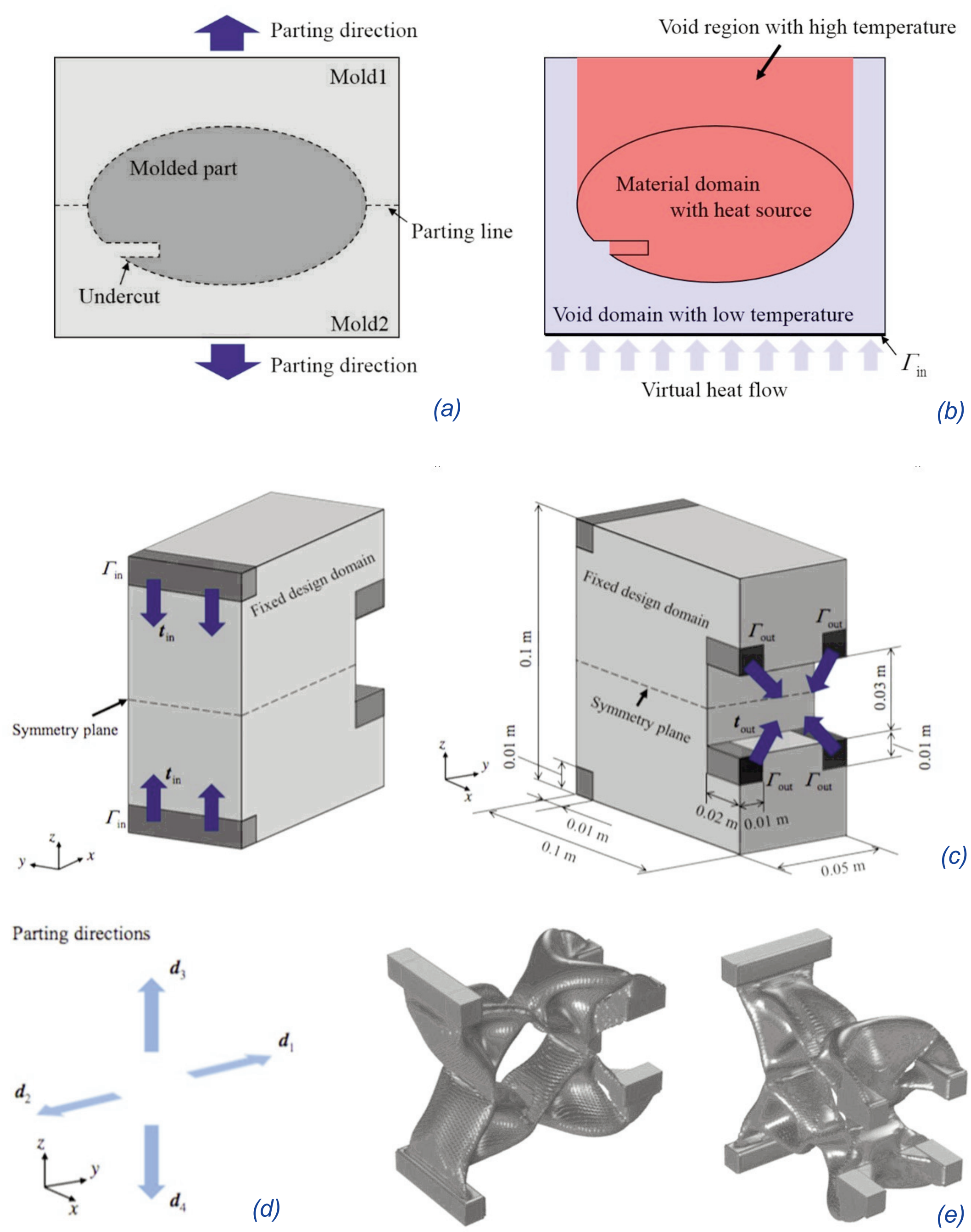


Figure 4:
Design example considering molding constraints

(a) Geometrical requirement

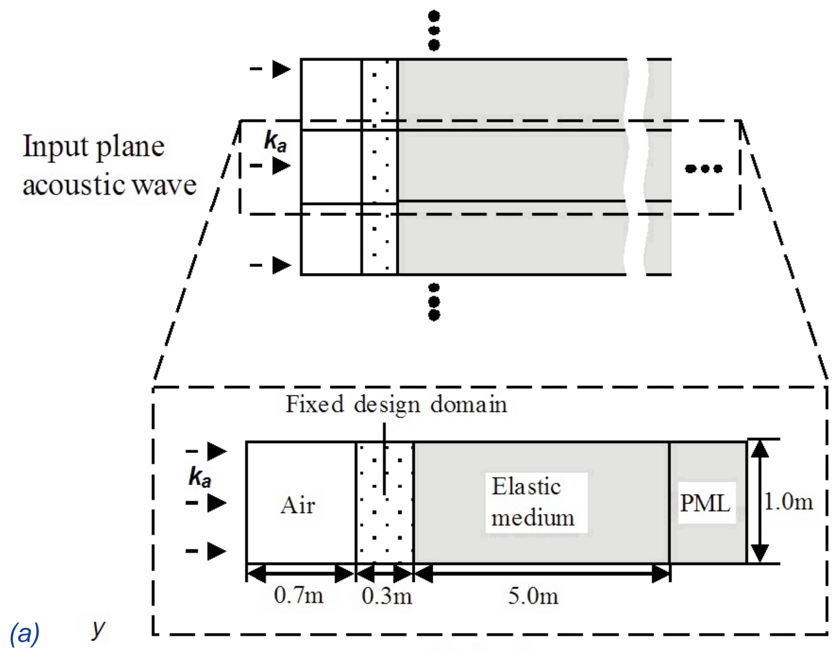
(b) Fictitious physical model

(c) Design domain and boundary conditions

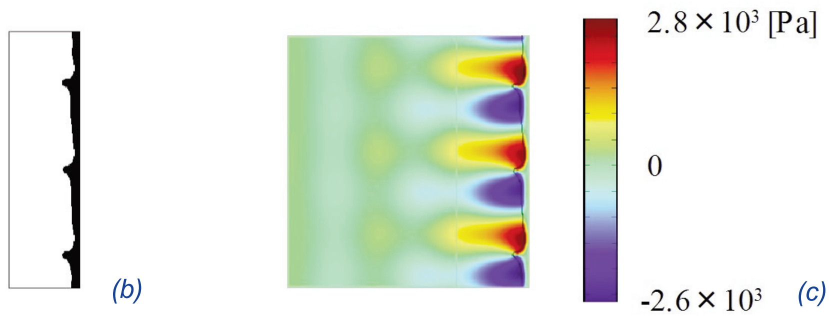
(d) Parting directions

(e) Optimal configuration

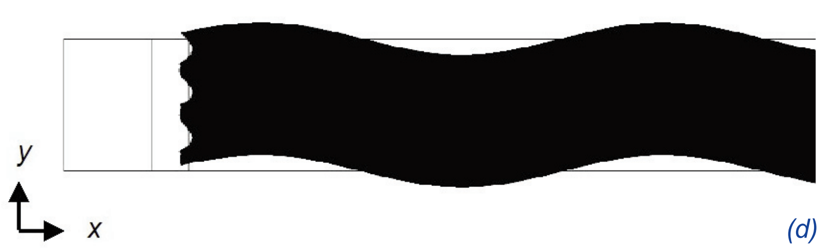
Figure 5:
Wave motion converting metasurface that converts longitudinal acoustic waves to transverse elastic waves



(a) Design model and boundary conditions



(b) Optimal configuration Incident wave frequency =1000Hz
(c) Acoustic pressure distribution



(d) Deformation pattern of optimal configuration

The proposed method is also applied for the design of an acoustic metasurface that can covert longitudinal acoustic waves to transverse elastic waves in an elastic medium in an acoustic-elastic coupled system [9]. *Figure 5* represents a design example for obtaining such a metasurface, with the design domain and boundary conditions shown in *Figure 5(a)*. A semi-infinite elastic material and air region are assumed. The metasurface is defined as a periodic array of unit cells in the y-direction, with the extent indicated by the rectangular outline. The unit cell contains the fixed design domain, air, and the elastic medium that includes a PML region. Incident plane acoustic waves impinge upon the left boundary of the air region in the unit cell and propagate through the air region. The frequency and amplitude of the incident waves are set to 1000Hz and 100Pa, respectively. The elastic material is assumed to be steel and the material distributions of the elastic material and acoustic medium (air) are optimized in the fixed design domain. An optimal configuration (black: elastic medium; white: air), acoustic pressure distribution, and the deformation pattern of the optimal configuration are shown in *Figure 5(b), (c), and (d),* respectively. We note that transverse elastic waves are dominant in the elastic medium, implying that the acoustic longitudinal waves were converted to transverse elastic waves.

Next, an acoustic metamaterial that exhibits a negative bulk modulus [10] is introduced as another example of our proposed method applied to an acoustic-elastic coupled system *(Figure 6).*

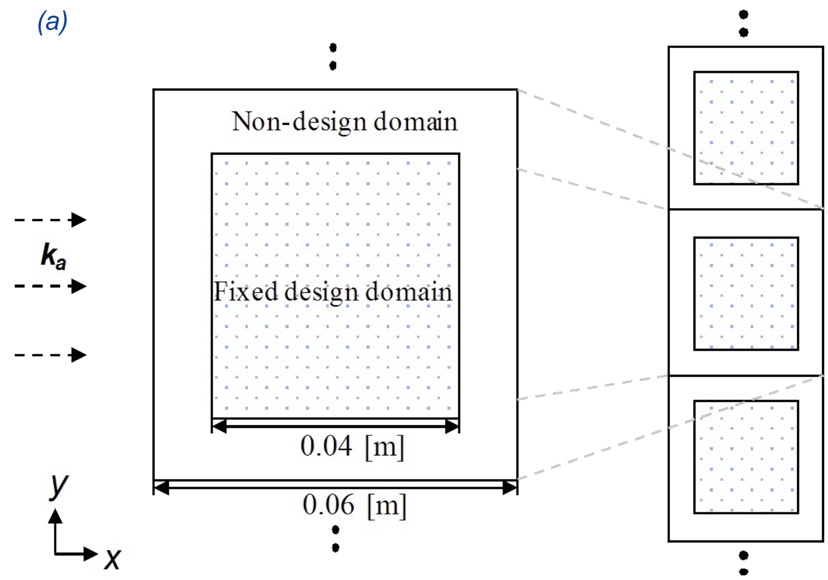
Figure 6(a) shows the design domain, under the assumption of metamaterial periodicity in the y-direction. Incident plane acoustic waves, with frequency and amplitude respectively set to 400Hz and 1Pa, impinge upon the left boundary of the unit cell. With rubber used as the elastic material, an optimal material distribution of air and elastic material is obtained. The optimal configuration shown in *Figure 6(b)* was obtained by minimizing the effective bulk modulus via an S-parameter-based approach. This configuration deforms outward at a phase of zero degrees, as shown in *Figure 6(c)*, confirming the negative bulk modulus of the metamaterial.

Conclusion

We introduced our developed topology optimization method and highlighted several applications for the design of mechanical structures, acoustic metasurfaces and materials.

We aim to further develop applications for multi-scale and multiphysics design problems that will yield innovative devices from the nanoscale to the macroscale.

Acknowledgements
The authors appreciate the support of the Strategic Innovation Promotion Program (SIP), a Japanese national project for developing conceptual design systems, and thank Quint Corporation for providing *Figure 3*.



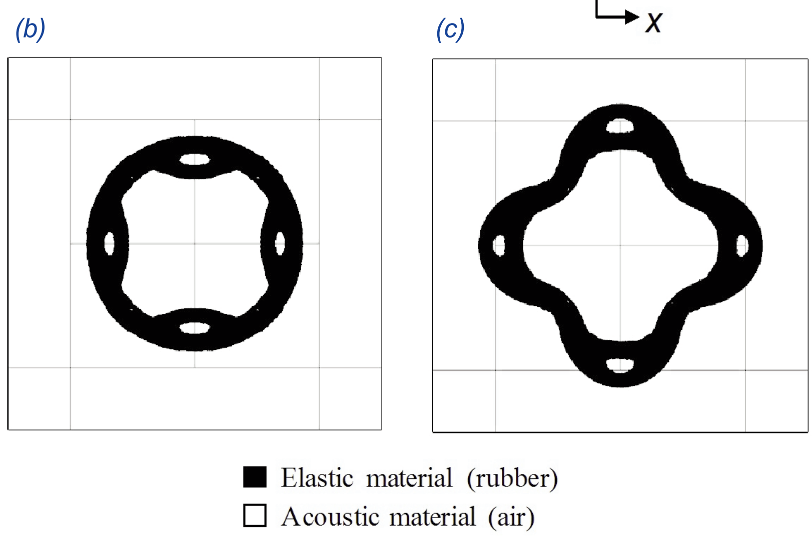


Figure 6:
Acoustic metamaterial which exhibits negative bulk modulus

(a) Design domain

(b) Optimal configuration
Incident wave frequency = 400Hz

(c) Deformation pattern of optimal configuration

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Constitutive Modeling Vital for Computational Mechanics

by
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Computational mechanics has assumed a significant role for accurate and economic analysis and design of engineering problems. There are a large number of computer procedures available such as the finite difference, finite element, and boundary element and meshless methods. However, the finite element method (FEM), one of the leading computer methods, is emphasized in this paper. The author believes that the FEM has achieved much wider acceptance in practice, teaching, and research. An article in the U.S. News and World Report magazine [1] states that among 25 *breakthroughs* that have influenced the modern society, Computer Aided Design with the finite element method is at the top.

Constitutive modeling defines the behavior of solids and contacts (e.g. interfaces and joints) under mechanical and environmental loadings and plays perhaps the most important role for realistic solutions from computer procedures. A great number of constitutive models, from simple to the advanced, have been proposed. Most of them account for specific characteristics of the material. However, a deforming material may experience *simultaneously* many characteristics such as elastic, plastic and creep strains, different loading (stress) paths, volume change under shear stress, effect of initial conditions, microcracking leading to fracture and failure, strain softening or degradation, failure and microstructural instabilities like liquefaction, and healing or strengthening under mechanical loads, temperature, fluids and chemicals. Hence, there is a need for developing unified models that account for these characteristics, as necessary, simultaneously. The constitutive modeling based on the unified disturbed state concept (DSC) theory with the finite element method, which can allow for the foregoing factors simultaneously, is the main objective of this paper.

A brief description of the previous models precedes details of disturbed state concept (DSC) that provides an unified and hierarchical way to develop constitutive models for a wide range of solid materials and contacts (interfaces and joints). A unified plasticity approach called hierarchical single surface (HISS) model, which contains most of the available plasticity models as special cases and used commonly to define the relative intact (RI) component in the DSC, described later, is also described; it is referred to as DSC-HISS model. For detailed information [2-4] can be consulted.

Objectives and Scope

Appropriate constitutive modeling that can account for the foregoing factors is vital for realistic and reliable solutions from computer procedures. Therefore, considerable research activities and number of publications have taken place over the last few decades. However, many of such models have addressed only specific factors. The DSC is considered to be a unique and unified approach that account for the above factors, simultaneously, and can be applied to a wide range of materials and contacts.

Publications on the DSC by the author and coworkers, and many others have taken place in *diverse* publication media (e.g. journals in engineering and physics) for materials such as geologic (soils and rocks), concrete, asphalt concrete, metals, alloys (e.g. leaded and unleaded solders), silicon and polymers, and interfaces and joints. Since reviews of available models have been presented in [2-6], their details are not included herein.

Comments: It is interesting to note that behavior of geologic materials like soils, rocks and concrete is affected by many of the above factors compared to other materials like metals and alloys. Hence, developments for advanced constitutive models for such materials have taken place perhaps more actively. Because of its generality and hierarchical nature, the DSC initially developed for geologic materials, has been used successfully for other materials such as metals, alloys, materials in electronic packaging, ceramics, silicon and polymers.

Constitutive Modeling- Brief History

Development and applications of various constitutive models are presented in [2-6]. Initially, constitutive models based on linear and nonlinear (piecewise linear) elasticity, were commonly used. In the earlier times, the computer (finite element) method was used mainly for structural mechanics problems by assuming that materials were linear and elastic. Nonlinear elasticity models such as hyperelasticity were used for some materials but they essentially allowed for elastic deformations, and did not find many applications to account for the realistic factors.

Since many materials exhibit plastic (irreversible) deformations, models based on the plasticity theory were adopted. Such conventional models are based on the Tresca, von Mises, Drucker Prager and Mohr Coulomb failure criteria in which it is assumed that the material behavior is linear elastic until the certain yield condition, and then experiences yield and plastic flow. The conventional plasticity models were used for structural (metals, alloys, etc.), and often for geologic materials. Note that the conventional plasticity models can predict ultimate or limit strength satisfactorily, but cannot predict accurately plastic behavior from the very beginning of loading, pre-peak and post-peak behavior. Many materials, geologic, concrete, asphalt, powders and some alloys and composites, can experience (plastic) yielding almost from the very beginning of loading; such a behavior is called *continuous yielding or hardening*; one of such model, developed for soils, is based on the critical state concept. Details in [2-4, 7].

Generalized Plasticity Models: Generalized plasticity model that can account for nonassociative and anisotropic hardening behavior, and the bounding surface models and their modifications have been presented in various publication cited in [3]. Sometimes such models based on the continuum assumption have been modified, by using ad hoc schemes or external enhancements [8], to handle discontinuous, softening or degradation; they allow for certain factors such as kinematic and anisotropic hardening, but they lack unified and hierarchical framework. Also, a main reason for softening or degradation is considered to be related to discontinuities due to microcracking; hence, such models may have limited validity for materials involving discontinuities. Usually the yielding is dependent only on the volumetric response (strains), and they do not allow for volume change before the peak stress condition.

Hierarchical Single Surface (HISS) Plasticity

The need for a unified and general plasticity model led to the development of the *hierarchical single surface* (HISS) plasticity model [2, 9,10]. The unified and hierarchical HISS plasticity model involves *a single and continuous* yield surface, can account for most of the factors listed above. However, without ad hoc modifications, it cannot account for discontinuities (inherent and induced), microstructural modifications leading to fracture and softening, and instabilities like failure and liquefaction. The yield surface, F, in HISS associative plasticity is expressed as *(Fig. 1)*:

$$F = \bar{J}_{2D} - (-\alpha \bar{J}_1^n + \gamma \bar{J}_1^2)(1 - \beta S_r)^{-0.5} = 0 \qquad (1)$$

where $\bar{J}_{2D} = J_{2D}/p_a^2$ is the non-dimensional second invariant of the deviatoric stress tensor, $\bar{J}_1 = (J_1 + 3R)/p_a$), J_1 is the first invariant of the stress tensor, R is the term related to the cohesive (tensile) strength, $\bar{c}$ (*Fig. 1(a)*),

$$Sr = \frac{\sqrt{27}}{2} \frac{J_{3D}}{J_{2D}^{1.5}} , \qquad (1a)$$

J_{3D} is the third invariant of the deviatoric stress tensor, n is the parameter related to the transition from compressive to dilative volume change, γ and β are the parameters associated with the ultimate surface, *Fig. 1(a)* and α is the yielding or hardening or growth function; in a simple form, it is given by

$$\alpha = \frac{a_1}{\xi^{\eta_1}} \qquad (2)$$

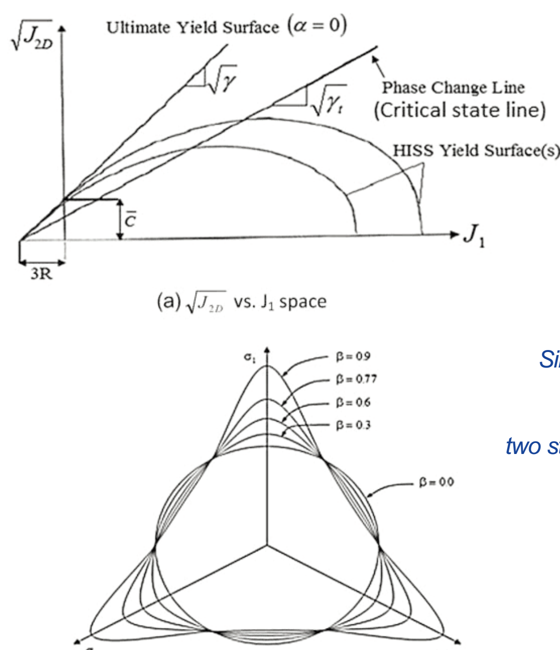
where a_1 and η_1 are the hardening parameters, and ξ is the accumulated or trajectory of plastic strains. In the HISS model, the yield surface grows continuously and approaches the *ultimate* yield, *Fig. 1*; it can include, as special cases, other conventional and continuous yield plasticity models.

Compressive and Tensile Behavior -HISS-CT Plasticity Model: It is difficult to develop the same constitutive model for both compressive and tensile yield behavior. However, the yielding behavior of many materials under compression and tension can be modeled using the same HISS plasticity framework; such a model that allows for both compression and tension, called, HISS-CT, have been presented [11].
l

Comments: The HISS plasticity model allows for continuous yielding, volume change (dilation) before peak, stress path dependent strength, effect of both volumetric and deviatoric strains on the yield behavior, and it does not contain any discontinuities in the yield surface. The HISS surface, *Eq. (1)*, represents a unified plastic yield surface, and most of the previous conventional and continuous yield surfaces can be derived as special cases [2]. Also, the HISS model can be used for non-associative and anisotropic hardening responses, etc

Creep Behavior: A number of models have been proposed for various types of creep behavior, viscoelastic (ve), viscoelasticplastic (vep) and viscoelasticviscoplastic (vevp); they are also based on the assumption of continuum material. A generalized creep model has been proposed under the DSC [2]; it is called the Multicomponent DSC (MDSC) which includes ve, vep and vevp versions as special cases.

Discontinuous Materials s



(b) $\sigma_1 - \sigma_2 - \sigma_3$ space; $\beta < 0.756$ required for convexity

Figure 1 : Hierarchical Single Surface (HISS) yield surfaces in two stress spaces

Models based on theories of elasticity, plasticity and creep assume that the material is initially continuous and remains continuous during deformation. However, it is realized that many materials contain discontinuities (microcracks, dislocations, etc.), initially and during loading. During deformation, they coalesce and grow, and separate, resulting in microcracks and fractures, with consequent failure. Since the stress at a point implies continuity of the material, theories of continuum mechanics may not be valid for such discontinuous materials. There are a number of available models to account for such discontinuities. Chief among those are considered to be fracture mechanics, damage mechanics, micromechanics, microcrack interaction, gradient and Cosserat theories [2, 8]. Most of them combine the effect of discontinuities and microcracks, with the continuum behavior; most of such models account for discontinuities by introducing external enrichments or enhancements into models such as the continuum damage [8]. In contrast, the DSC allows for the effects implicitly and does not require external enrichments. Models based on fracture mechanics usually assume a preexisting crack or fracture at a selected location(s) in the structure. Under loading, microcracking usually initiates at the assumed crack, and then it grows. Stress intensity factors and the J-integral methods are often used to model development and propagation of fractures. Such procedures based on preexisting cracks may not be always realistic because it may not be possible to know the locations and dimensions of cracks a priori. In reality, cracks can initiate and grow at any location(s) within the material, depending on the loading, composition and type of the material and boundary conditions. The DSC allows for development of cracks and their growth at natural locations and does not require introduction of cracks in advance. The continuum (conventional) damage approach [12] is rooted in the idea that the physical occurrence of microcracking and fracture can be evaluated on the basis of value of the *damage parameter.* A major limitation of the conventional damage approach is that the damaged part of the material is assumed to have *no strength*, i. e. it cannot carry any stress. Thus the damaged part does not contribute to the deformation and strength of the material. In reality, before the material fractures completely, the damaged or (micro) cracked part does possess certain strength, interacts with the undamaged part, and influences the overall observed behavior. Thus, the conventional damage model could result in a local model which may cause computational difficulties, e.g., spurious mesh dependence. Note that it is very important to include the interaction between the damaged and undamaged parts for developing a consistent model. The DSC model allows for the coupling between the RI and FA parts, described later. There is a basic difference between the damage and DSC models; the former is based on physical damage (cracking), while the DSC is based on the behavior of a material considered as a mixture of RI (continuum) and fully adjusted (FA) parts, whose behavior are coupled to yield the observed response [2]. Furthermore, the DSC can be used to characterize stiffening and healing in which the disturbance can decrease [13].

Enrichment of Conventional (Damage), Microcrack Interaction Model: Various schemes have been proposed based on the enrichment of conventional damage model and microcrack interaction in order to account for the coupling between the behaviors of the undamaged and damaged parts in a material element [8]. Various enrichments which are combined with the continuum response can include such models such as the Cosserat and gradient plasticity theories, and microcrack interaction [14]. The micromechanical approach involves definition of constitutive equations at the micro or particle level, and then integration of the micro level response to lead to the macro behavior. This is a logical procedure; however, at this time, it can be difficult to define the microlevel response as appropriate (laboratory) tests are not readily available. Very often, therefore, the micro response is approximated from macro response from tests on *finite sized* specimens, which appears to be a contradiction. Also, the process of integration from micro (part) to macro (whole) may not allow properly for the interaction of particles in complex material systems [2, 15].

DISTURBED STATE CONCEPT (DSC)

The DSC is a general and unified approach that can accommodate most of the forgoing factors including the effect of discontinuities that influence the material behavior, and provides a hierarchical framework that can include many of the above models as special cases [2-4, 16-20]. One of the important attributes of the DSC is that its mathematical framework can be specialized for contacts (interfaces and joints), thereby providing consistency in using the same model for both solids and contacts.

The origin of the DSC constitutive modeling can be traced to the publications by Desai [16, 17] on the subject of behavior of overconsolidated soils and free surface flow in porous materials. The DSC is based on rather a simple idea that the behavior of a deforming material, considered as a mixture of components of various material states, can be expressed in terms of the behaviors of the components. Thus, the behavior of a dry material can be defined in terms of the behavior of material in continuum (called relative intact-RI) state, and microcraked part which approaches, in the limit, to the fully adjusted (FA) state. A schematic of the DSC is depicted in *Fig. 2.*

DSC Equations

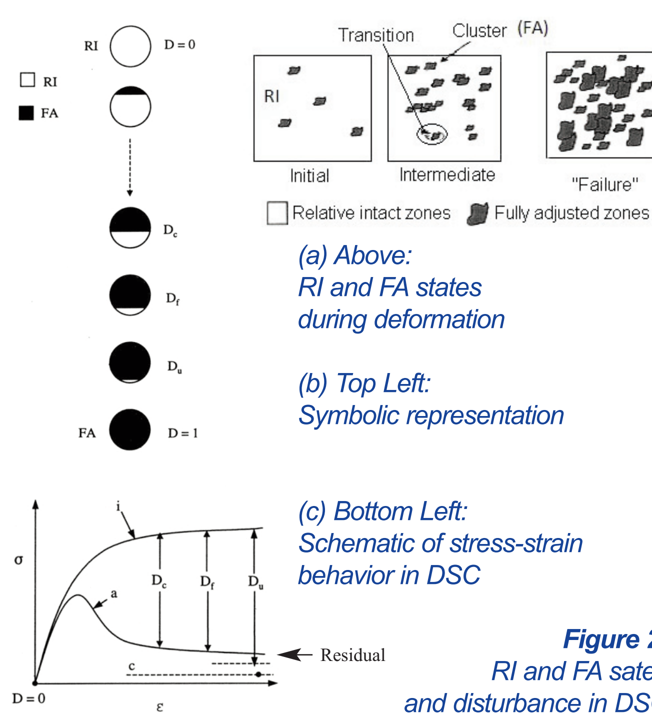
Once incremental DSC equations based on equilibrium of a material element can be derived as:

$$d\sigma_{ij}^a = (1-D)\, d\sigma_{ij}^i + D d\sigma_{ij}^c + dD\, (\sigma_{ij}^c - \sigma_{ij}^i)$$

or (3)

$$d\sigma_{ij}^a = (1-D)\, C_{ijkl}^i\, d\epsilon_{kl}^i + D C_{ijkl}^c + d\epsilon_{kl}^c + dD\, (\sigma_{ij}^c - \sigma_{ij}^i)$$

where a, i and c denote observed, RI and FA responses, respectively, σ_{ij} and ε_{ij} denote stress and strain tensors, respectively, C_{ijkl} is the constitutive tensor, d denotes increment



(a) Above: RI and FA states during deformation

(b) Top Left: Symbolic representation

(c) Bottom Left: Schematic of stress-strain behavior in DSC

Figure 2: *RI and FA sates and disturbance in DSC*

and dD is the increment or rate of D. The conventional continuum (elasticity, plasticity, creep) models can be derived as special cases by setting $D=0$ in Eq. 3. If $D \neq 0$, the equations account for microstructural modifications in the material leading to fracture, failure, degradation (softening) and instability like failure and liquefaction (in saturated materials), and stiffening or healing. Failure and liquefaction can be defined corresponding to the critical disturbance, D_c, *Fig.3,* obtained from measured response of the materials.

The RI part can experience microcracking due to self-adjustment or self-organization, which can approach an asymptotic FA state like the critical state, which can be considered as constrained liquid-solid state and defined accordingly [2], or constrained liquid state defined by using the bulk modulus. It is called the Fully Adjusted (FA) state because the RI material experiences transition, in the limit to the FA state, which can denote full failure. *Figure 3* shows the RI (i) and FA (c) responses and disturbance in the DSC.

The behavior of the FA part is unattainable (or unmanifested) in practice because it cannot be measured; therefore, a state, somewhere near the residual or ultimate, *Fig. 2(c)* can be chosen as approximate FA state. The space between the RI and FA denoted by (i) and (c) , respectively, can be called the domain of deformation, whose observed or average behavior (can be called manifested since it can be measured) occurs between the RI and FA states, *Fig. 2*. The deviation of the observed state from the RI (or FA) states is called disturbance, and is denoted by D, which the difference between the RI and observed behavior or difference between the observed and FA behavior.

By defining the observed material behavior in terms of RI (continuum) and fully adjusted parts, the DSC provides for the interaction between two parts of the material behavior rather than on the behavior of particle(s) at the micro level. Thus, the emphasis is on the modeling of the collective behavior of interacting mechanism in clusters of RI and FA states thereby yielding a model that is considered to be holistic. These comments are similar to those in the self-organized criticality concept [15], which is used to simulate catastrophic events such as avalanches and earthquakes. Thus, the definition of the DSC is not based on the behavior at the microlevel (say, as in micromechanics); rather it is based on the behavior of the material clusters in the RI and FA states defined from the measured behavior in those states, *Fig. 2c.*

The behaviors of the RI and FA can be defined from laboratory or field tests, and then the observed behavior is expressed in terms of the behaviors of the RI and FA parts. Let us, for the time being, assume that the material is continuous from the beginning and remains so during deformation; such a behavior is called that of RI State, which contains no disturbance. However, the initial disturbance can also be included in the DSC. Some of the ways to define RI and FA responses are given below.

RI State: Figure 3a shows the continuum response as linear elastic, which can be considered as the RI state. However, the observed response can be nonlinear (elastic), due to factors such as cracking. The FA response can be assumed to have a small finite strength. The disturbance can be defined as the difference between linear elastic and nonlinear elastic responses. *Figure 3b* shows a strain softening response. Here the RI response can be assumed to be nonlinear elasticplastic and the FA response based on the critical state concept. For the cyclic response [2], the RI behavior can be adopted as the extended response in the first cycle. The FA response can be assumed to be asymptotic as it becomes steady (c) after a number of cycles.

In many cases, the RI behavior can be assumed to be linear elastic defined by the initial slope. However, if the material behavior is nonlinear and involves effect of other factors such as coupled volume change behavior under shear loading, such an assumption will not be realistic. Hence, very often, continuous yield or HISS plasticity is adopted as the RI response. It can be defined by extending the initial part of the observed curve, *Fig. 3a*, or by integrating the incremental (plasticity) constitutive equations after finding the parameters based on the initial part of the response, before the peak stress [2].

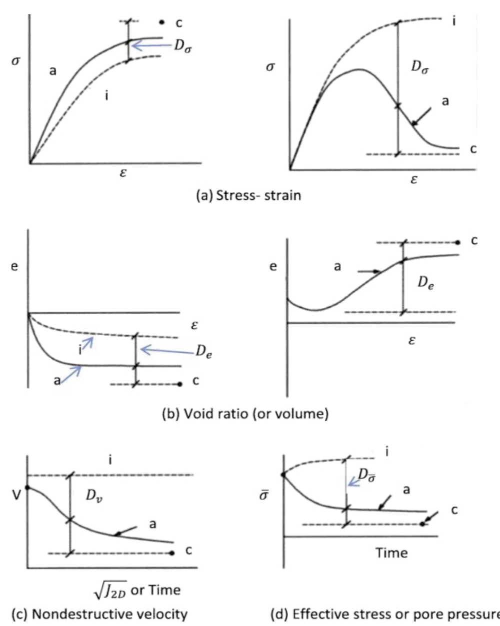


Figure 3: *Various tests behavior to define disturbance*

FA State: An easy way is to assume that the material in the FA state has no strength, just like in the classical damage model [12]; this assumption is not realistic. The other assumption is to consider that the material in the FA state can carry hydrostatic stress like a constrained liquid, in which case the bulk modulus (K) can be used to define the response of the FA state; this is similar to the assumption of plastic flow after yield in classical plasticity. The FA material can be considered as of liquid-solid like in the critical state [2, 7], when after continuous yield, the material approaches thestate at which there is no change in volume or density or void ratio under increasing shear stress. For fluid saturated materials with drainage with time, the RI behavior can be assumed to be near zero time, and the FA response can be assumed like that of a constrained liquid. A description of the DSC for partially saturated materials is given in [2].

Disturbance: As stated before, disturbance defines the coupling between the RI and FA states, and can be expressed as

$$D = D\,[\xi, w, S, \phi, t(N), T, \alpha_i] \qquad (4)$$

where ξ and w denote internal variables such a accumulated plastic strain and (dissipated) energy, S is entropy (disorder), ϕ is free energy, t is time, N denotes number of loading cycles, T is temperature and α_i (I = 1, 2,…..) denote factors like environmental effects, dislocations, and impurities. Various representations for disturbance from measurements including nondestructive data, entropy and dislocation are described below.

Disturbance can be determined based on the stress-strain behavior, *Fig. 3(a)*. It can be determined from other tests like void ratio (specific density) vs. strain, *Fig. 3(b)*, nondestructive behavior such a for P- and S- waves velocities, *Fig. 3(c),* fluid (pore) water pressure or effective stress ($\bar{\sigma}$) vs. time or number of cycles , *Fig. 3(d)*, entropy and dislocation [2]. *Figure 4* shows the schematic of the disturbance (D) as function of ξ_D or number of cycles (N) or time (t) as affected by appropriate factors; here D_c, D_f and D_u denote initiation of microcracking or fracture, failure and ultimate disturbance, respectively. The critical disturbance, D_c, can be used to identify initiation and growth of microcracking (or fracture) at any locations in material, based on its value determined from laboratory tests, at various incremental steps in the finite element procedure [2-4, 19, 20]. Thus, as in the fracture mechanics, it is not necessary in the DSC to adopt locations of cracks, *a priori*.

The disturbance can defined in two ways, (1) from measurements, *Fig. 3*, as stated before, and (2) by mathematical expression in terms of internal variables as in Eq (4)

From measurements, for example:

Stress-strain: $$D_\sigma = \frac{\sigma^i - \sigma^a}{\sigma^i - \sigma^c} \quad (5a)$$

Fluid pressure: $$D_p = \frac{p^i - p^a}{p^i - p^c} \quad (5b)$$

Nondestructive velocity: $$D_v = \frac{V^i - V^a}{V^i - V^a} \quad (5c)$$

where σ^a is the measured stress, p^a is the measured fluid pressure, and V^a is the measured nondestructive velocity.

DSC and Thermodynamics

The connection of the DSC theory to thermodynamics, physics and philosophy was undertaken from the beginning of its development. It was related to thermodynamics by expressing D in terms of the rate of dislocation density, Peirel's energy and Boltzmann constant [13, 21]. The connection between disturbance and rate of dislocation density, $\dot{N}m$, [13,21, 22], is expressed as

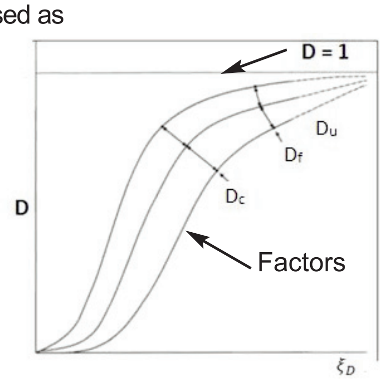


Figure 4:
Disturbance vs. ξ_D
(or time or no. of cycles)
under required factors

$$\dot{N}m = K N_m k_0 \left[(1\text{-D}) \sqrt{J^i_{2D}} - \lambda \sqrt{N_m} \right]^{p+r} e^{-Q/KT} \quad (6)$$

where $\sqrt{N_m}$ is the back stress, K is Boltzmann's constant, Q is Peirel's energy, K , p and are material constants, $k_0 = B_0\ \tau_0$ is mobility, τ_0 is the resolved stress and $\sqrt{J^i_{2D}}$ is the shear stress in the RI phase. The analyses in [13] showed a close correlation between $\dot{N}m$ and D. The disturbance was later expressed in terms of entropy [23].

In addition to physics, the DSC can also be connected to philosophy, e.g. *sat* and *asat* (invariant –FA state) and transient or measurable (a) states, respectively, as in the Vedic concept regarding matter in the universe [2, 24].

Mathematical Expression for D

An equation for disturbance, D, can be expressed using the (Weibull) function in terms of internal variable such as accumulated (deviatoric) plastic strains (ξ_D) or plastic work:

$$D = D_u \left[1\text{-exp} (\text{-A}\ \xi_D^Z) \right] \quad (7)$$

where A, Z and D_u are the parameters. The value of D_u is obtained from the (approximate) ultimate FA state, *Fig. 2c*. Equations 5 can be used to find the disturbance, *Fig. 3*, at various points on the response curves, which are substituted in *Eq. 7* to find the parameters, A and Z. Note that the expression in *Eq. 7* is similar to that used in various areas such as biology to simulate birth to death, or growth and decay, and in engineering to define damage in classical damage mechanics, and disturbance in the DSC.

Parameters: The parameters in the DSC usually consist of: Elastic (E, ν); HISS plasticity for RI (γ, β, n; a_1 η_1, R ($\bar{c}$); Critical state for FA ($\bar{m}$, λ, e_o), Disturbance (A, Z, D_u). Most of these parameters in the DSC have physical meanings, i.e. almost all are related to specific states in the material response. Their number is equal or lower than that of previously available model of comparable capabilities. They can be determined from standard laboratory tests such as uniaxial, shear, triaxial and/or multiaxial. The procedures for the determination of the parameters are provided in various publications [2-4, 10]. The hierarchical property in the DSC-HISS model allows adoption of parameters only for the factors needed for the behavior of a specific material, e.g. if yielding and disturbance are not involved, only the elastic parameters are needed, and so on.

CONTACTS: INTERFACES and JOINTS

Behavior at contacts or interfaces between two (different) materials plays a significant role in the overall response of an engineering system [2, 25, and 26]. One of the main advantages of the DSC is that its mathematical framework can be specialized for contacts (interfaces and joints). Hence, use of the same framework in the DSC for both solids and contacts provides required consistency. This is in contrast to the common use of different models for solids and contacts in the same problem, e.g. a plasticity model for solids and bilinear elastic model for interfaces. A brief description of the DSC for interfaces is given below.

Relative Intact (RI) and FA Responses: As described in [2, 25, 26] the RI and FA responses can be defined based on appropriate interface (normal and shear) tests under different normal stresses, roughness, amplitudes of cyclic loadings, etc.

The yield function specialized from *Eq. (1)* for two-dimensional interface is given by

$$F = \tau^2 \ \alpha\sigma_n^n \ - \ \gamma\sigma_n^q = 0 \qquad (8)$$

where is the shear stress, σ_n is the normal stress, which can be modified as σ_n + R, R is the intercept along σ_n axis, γ is the slope of ultimate response, n = phase change parameter, which designates transition from compressive to dilative response, q = governs the slope of the ultimate envelope (if the ultimate envelope is linear, q = 2), and α is the growth or yield function which can be expressed in terms of factors as in *Eq. (4).*

Disturbance Function: Disturbance can be derived from measured (shear) stress- (normal) strain, volumetric, effective stress (or pore water pressure) and cyclic behavior of the contact as in the case of solids, *Fig. 3*.

ANALYSIS of DSC

For reliable and consistent predictions, a constitutive model must satisfy certain mathematical characteristics such as localization and mesh dependence. The DSC is based on the interaction between the RI and FA parts. As a result, it can provide freedom from spurious mesh dependence, and consistent localization; details of these aspects are presented in [2-4, 27, 28].

Applications and Validations

The DSC-HISS model is validated at specimen and boundary value problem levels. Predictions from the finite element procedure with the DSC-HISS model have been compared with measurements from the laboratory and the field for a wide range of problems in Geomechanics/geotechnical engineering, structural mechanics, earthquake analysis including liquefaction as a microstructural instability, rock mechanics, glacial mechanics, electronic packaging (composites) , physics and chemistry [2-4,24].

CONCLUSIONS

Computational mechanics has advanced rapidly over the last few decades. However, there are some issues that influence significantly results from computer procedures. Constitutive modeling of solids and contacts is one of the issues that play a key role in obtaining realistic solutions from computer procedures. Hence, constitutive modeling is emphasized in this paper. A brief review of a number of available models is presented. Then the disturbed state concept (DSC-HISS) is described, which provides a unified constitutive modeling approach for engineering materials and contacts and allows for elastic, plastic and creep strains, stress path dependence, volume change under shear, microcracking and fracturing, softening and degradation, stiffening or healing, all within a single, hierarchical framework. Its capabilities go well beyond other available models yet lead to significant simplifications for practical applications. A major advantage of the DSC-HISS approach is that its formulation for solids can be specialized for interfaces and joints. The DSC-HISS model has been applied successfully for characterization of behavior of many materials such as cohesive and cohesionless soils, rocks, concrete, asphalt, ceramics, metals, alloys, polymers, silicon and effect of chemicals.

Finally, the importance of appropriate constitutive modeling for realistic solutions using computer methods cannot be overemphasized. ●

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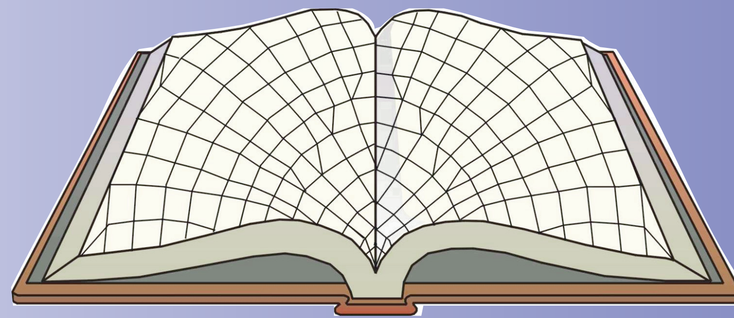
THE FINITE ELEMENT METHOD FOR SOLID AND STRUCTURAL MECHANICS



O.C. Zienkiewicz, R.L. Taylor and D.D. Fox
Elsevier, Amsterdam, 2014 (7th edition)

BOOK REVIEW

ISBN: 978-1-85617-634-7, 624 pages, soft cover, $86 (List Price).
Contents: Preface; 1: General Problems in Solid Mechanics and Nonlinearity; 2: Galerkin Method of Approximation: Irreducible and Mixed Forms; 3: Solution of Nonlinear Algebraic Equations; 4: Inelastic and Nonlinear Materials; 5: Geometrically Nonlinear Problems: Finite Deformation; 6: Material Constitution for Finite Deformation; 7: Material Constitution Using Representative Volume Elements; 8: Treatment of Constraints: Contact and Tied Interfaces; 9: Pseudo-Rigid and Rigid-Flexible Bodies; 10: Background Mathematics and Linear Shell Theory; 11: Differential Geometry and Calculus on Manifolds; 12: Geometrically Nonlinear Problems in Continuum Mechanics; 13: A Nonlinear Geometrically Exact Rod Model; 14: A Nonlinear Geometrically Exact Shell Model; 15: Computer Procedures for Finite Element Analysis; Appendix A: Isoparametric Finite Element Approximations; Appendix B: Invariants of Second-Order Tensors; Author Index; Subject Index.

This is the second of three volumes which together form an encyclopedic treatment of the Finite Element Method (FEM). The first volume covers the basics of FEM, while the third volume is about FEM for fluid dynamics. The present volume, on FEM for solid and structural mechanics, has been published in 7 editions. The 1st edition was published in 1967 by McGraw Hill. The previous edition was published by the first two authors in 2005, when Olek Zienkiewicz, who is one of the pioneers of FEM, was still alive. The second author, Bob Taylor, professor emeritus from UC Berkley, is the world expert in modeling structures and solid continua. David Fox, from Dassault Systèmes SIMULIA, who has almost 30 years of experience in FE technology, has joined as a third author of this 7th edition.

Praising this book is almost superfluous. The three volumes are considered corner stones in FEM literature. The previous editions were very well accepted by generations of readers. The main update in the 7th edition is the material on geometrically exact rod and shell models, which is an excellent addition to the book. What has probably been appealing to many readers about these volumes is the combination of "solid" theory, which is advanced but not very rigorous mathematically (e.g., not many function spaces are mentioned), and practical procedures, which are application-oriented. Of course, some readers may prefer more rigor (or less), but this is a matter of personal orientation. There is a whole spectrum of FEM books with varying amounts of "mathematics" and "engineering", where the extremes may be represented, say, by the book by Ciarlet (extremely mathematical) at one end of the spectrum, and the book by Irons and Ahmad (which is mostly text and illustrations with few equations) at the other end. I would say that the present book, or at least its first two parts (see later), is centrally located in this spectrum, and in this category it is perhaps the best book available on the subject.

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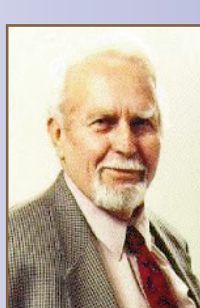
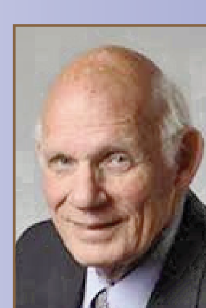
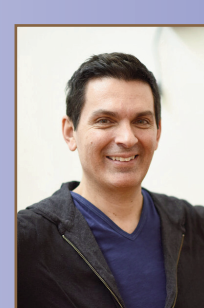


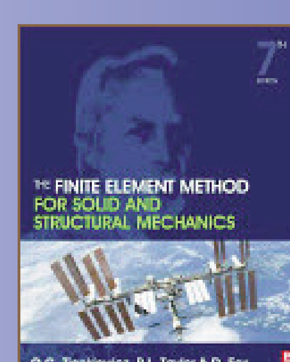
O.C. Zienkiewicz



R.L. Taylor



D.D. Fox



The book is inviting to read, with a nice structure and quite a few figures, some of them colorful. There are comprehensive author index and subject index at the end.

The first part of the book, consisting of Chapters 1-6, is a thorough treatment of FEM for nonlinear solid mechanics. Chapters 7-9, which constitute the second part, cover advanced topics in FEM for solid mechanics, namely materials with microstructures (and the use of RVEs), contact and rigid-flexible body motion. These first two parts were mainly written by the first two authors. The third part, consisting of Chapters 10-14, focuses on FEM for nonlinear structural mechanics, i.e., rods and shells. The third author has contributed mainly to this part, which builds on his earlier work with the late Juan Simo. The book is dedicated to Zienkiewicz and to Simo.

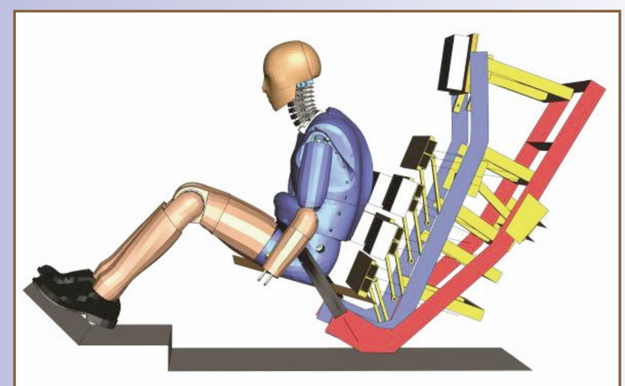


Figure 1: *An Abaqus BioRID II model. This is Fig. 9.7 in the book, which is courtesy of Dassault Systèmes SIMULIA*

The book assumes basic knowledge of FEM. In fact, I recommend that readers go through at least some parts of the first volume, in order to get used to the notation, terminology and style of writing, before starting reading this volume. As an example for why this is recommended, in section 1.2 and in Table 1.1 the authors refer to the single-index array σ, with stress components σ_i, as a 'matrix' rather than as a 'vector.' The reason is that a 'vector' in this book is not just a list of numbers (as a vector in a computer code) but a tensor of order 1, which can be viewed as a geometrical object, and which obeys the standard vector transformation rule. Thus, the list of three displacement components is a vector, but the 1-index list of all the stress components is a matrix (having one column). This is a nice distinction, not adopted in many other books, but it is not explained here, since it is taken for granted that the reader understands this. Also, the fact that stress is actually a 2nd-order tensor, but that in the context of FEM it is convenient for practical purposes to write its components in a one-column matrix, is not pointed out. Again, a reader who has read the first volume will already be aware of this. Of course, these and other such possible sources of slight confusion would not pose a serious obstacle to most readers, even without consulting the first volume.

The introductory Chapters 1 and 2 rapidly go through the basics of nonlinear solid mechanics and Galerkin FE formulations. The problem considered is nonlinear and time-dependent from the outset. The linear and static cases are treated as special cases. Variational principles, including the Hu-Washizu and Hellinger-Reissner principles, are also briefly presented. In Chapter 2, both irreducible and mixed formulations are discussed. One of the latter is a 3-field mixed method, where the fields are the volume strain (discontinuous), the pressure (discontinuous) and the displacement (continuous). Another mixed method involves two continuous fields (pressure and displacement).

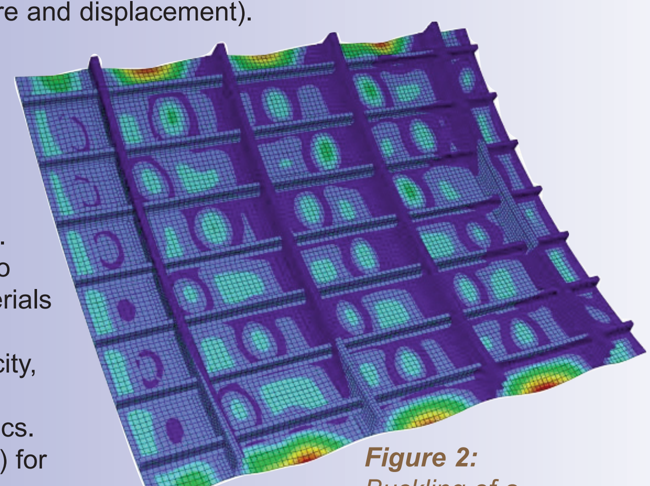


Figure 2: *Buckling of a skin-stringer panel. This is Fig. 14.14 in the book, which is courtesy of Dassault Systemes SIMULIA*

Chapter 3 discusses solution methods for nonlinear algebraic systems, including the Newton method, Modified Newton, quasi-Newton updates, line search and displacement control. Incidentally, Eq. (3.2), which is supposed to be the generic nonlinear system of equations, is actually the definition of the residual, namely the right hand side (which is zero) is missing. It is strange that such a mistake remained unobserved after so many editions. Chapter 4 deals with FE formulations for materials other than linear elastic. This includes viscoelasticity, time-independent plasticity, non-associative and generalized plasticity, creep, J2 plasticity and viscoplasticity. Non-uniqueness and localization in elasto-plasticity are discussed among other topics. Chapter 5 covers FE formulations (both irreducible and mixed) for finite deformation problems, and Chapter 6 combines material nonlinearity with geometrical nonlinearity (large deformation).

Chapter 7 discusses the treatment of materials that have a microstructure. A powerful methodology for such materials is the use of Representative Volume Elements (RVE), which allows the representation of the micro-structure at the macro level, as the introduction in section 7.1 explains nicely. The theory is applied to two examples: cylindrical bending of a composite plate, and an elasto-plastic behavior of a rectangular plate.

One question in this context is the type of boundary conditions to be used on the boundaries of the RVE. The authors discuss the cases of periodic and essential boundary conditions. Although I did not find this written down explicitly, it seems that the numerical results are not very sensitive to the choice of the RVE boundary conditions. "Taylor's assumption" is mentioned a few times in this chapter, although it would have benefited the readers to define, explain and justify it more clearly. This assumption, which concerns a situation where two very different scales interact, was first made by G.I. Taylor in the context of turbulent flow. In the context of solid mechanics, this is the assumption that all the micro-structural constituents undergo the same deformation as the macro-scale one.

Chapter 8 is an excellent survey of FE methods for contact problems. Node-node, node-surface and surface-surface contact are all covered, both without and with friction. Chapter 9 covers computational methods for pseudo-rigid and rigid-flexible solids. The main technique for connecting a rigid body to a flexible body is that of using Lagrange multipliers. One example is the Abaqus BioRID II model shown in Fig. 1, which is used to evaluate the risk of neck injury during a rear-end car collision.

As mentioned above, Chapters 10-14 focus on FEM for nonlinear problems in structural mechanics. This is non-standard material which is very well written but is quite "heavy". Of course, this is not the fault of the authors, but simply reflects the extreme complexity of the subject, which is arguably the most complicated area in computational solid mechanics.

Chapter 10, on linear shell theory, starts with the necessary mathematical background, and with a short summary of 3D linear elasticity, but presented in a non-conventional way, using curvilinear vector expressions, so that it will later easily lend itself to reduction to the shell equations. Then comes the derivation of linear shell theory, with its variational and FE formulations. The chapter ends with some numerical examples. Chapter 11, which is purely mathematical, is an introduction to the parts of differential geometry necessary for the development of nonlinear rod and shell theories. Chapter 12 discusses geometrically nonlinear problems in continuum mechanics. There is some overlap with Chapter 5, but the approach here is more general and abstract, and use is made of convective coordinates to describe the momentum balance equations.

Chapters 13 and 14 discuss nonlinear geometrically exact rod and shell FE models, respectively. The word "exact" here implies that the rod and shell formulations are obtained from the 3D theory without the usual approximation that relies on the thinness of the structure. In both chapters, the consistent tangent stiffness matrix is computed, which is a key ingredient for the success of the scheme. Numerical examples end these chapters: Fig. 2 shows the buckling of a skin-stringer panel, and Fig. 3 shows a snapshot from a car crash simulation.

Chapter 15 describes the code FEAP pv, which is freely available (including the source, written in standard Fortran) on the website of the second author.

In summary, this is a highly recommended book in computational solid and structural mechanics, written by renowned experts. It is kept up to date in each new edition. Its main strength is that it covers quite advanced topics, yet it is very practical throughout.

Figure 3:
A car crash simulation
This is Fig. 14.15 in the book, which is courtesy of Livermore Software Technology Corporation

Polish Association for Computational Mechanics

Non-linear Finite Element Analysis with particular Focus on Time-Dependent Problems

for all inclusions under ***PACM***
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mieczyslaw.kuczma@put.poznan.pl

Polish Association for Computational Mechanics organized recently a three-day course entitled Non-linear Finite Element Analysis with particular Focus on Time-Dependent Problems, which was held in Poznań at the Poznan University of Technology (PUT) on 21-23 February 2017. The course was addressed to young researchers and PhD students who are interested in thermo-mechanics and computational mechanics, and especially in the foundations of problems leading to implicit finite element programs and/or differential-algebraic equations (DAEs). The lecturer, Prof. Stefan Hartmann from the Clausthal University of Technology (Germany), delivered excellent lectures on the wide spectrum of issues including the following topics: viscoelasticity, rate-independent plasticity, viscoplasticity, principle of virtual displacements and its discretization using finite elements, temporal discretization using the backward Euler method to solve DAEs, Newton-Raphson method versus multilevel Newton method, higher order time discretization using diagonally-implicit Runge-Kutta methods, time-adaptivity, finite deformations, thermo-mechanics and thermo-dynamics.

The co-organizer of the course was the Commission of Mechanical and Civil Engineering Sciences of the Polish Academy of Sciences, Poznań Branch, and the course was supported by Rector of PUT – Prof. Tomasz Łodygowski, and by Dean of the Faculty of Civil and Environmental Engineering – Prof. Tomasz Mróz. A number of PACM members (Mieczysław Kuczma, Wojciech Sumelka, Magdalena Łasecka-Plura, Katarzyna Rzeszut, Bożena Kuczma) were involved in the organization of the course. Altogether some 30 young researchers and PhD students from Polish universities and research institutes participated in the course. ●

Figure 1:
Prof. Stefan Hartmann lecturing at the Course on Non-linear FEA

Figure 2:
Participants of the Course on Non-linear FEA in Poznań

25th UK Conference on Computational Mechanics
April 2017

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C. E. Augarde
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The 25th **UKACM Conference** was held at the School of Engineering at the University of Birmingham on **12th and 13th April 2017**. The University of Birmingham has long and extensive links with IACM, ECCOMAS and related associations, and we were delighted to have the opportunity to host the conference. This year's conference provided an exceptional opportunity for presenting and discussing research findings in many areas of mechanics, with an emphasis on interdisciplinary aspects. It extends the success of the previous 24 conferences which have proved to be particularly useful events for bringing together researchers from different disciplines, and especially for providing young researchers with opportunities to present their work. This year's conference hosted more than 80 papers from over 15 different countries and nearly 40 different institutions, covering a wide range of topics including solid and structural mechanics; failure, fracture and damage; geo-mechanics; fluid mechanics and biomechanics, to name but a few. The conference was preceded by the "UKACM School" on 11th April, where lectures were delivered on the topics of train aerodynamics and large-scale topology optimisation.

Particular attention was paid to the area of CFD this year evident from the keynote lectures delivered by Prof Spencer Sherwin, Prof Mike Hartnett and the UKACM School speakers. Prof Spencer (Imperial College London) delivered a plenary lecture on "Spectral/hp element techniques for high Reynolds number flow simulations relevant to Formula One", while Prof Hartnett (NUI Galway) presented his research findings on "Modelling complex flows in coastal urban floodplains using multi-scale spatial nesting". Prof Chris Baker and Dr Hassan Hemida (both Birmingham University) gave a joint lecture in the UKACM School on "The context and use of Computational Fluid Dynamics in the study of train aerodynamics".

Dr Fehmi Cirak (Cambridge University) delivered an interesting and thought-provoking plenary lecture on "Integrating geometric design, analysis and optimisation" which was of particular interest to the conference participants and Prof Michal Kočvara (School of Mathematics, Birmingham University) delivered an exciting talk on "New Numerical Tools for Very Large Scale Topology Optimization". The conference was also an opportunity to remember the late Prof Nenad Bicanic (1945-2016) who was among those who established the UKACM (formerly known as ACME) over 25 years ago alongside Prof Zienkiewicz. Next year's conference will be absorbed into the ECCOMAS ECCM-ECFD 2018 conference in Glasgow (see www.eccm-ecfd2018.org) and in 2019 UKACM will be at City University in London. ●

Asaad Faramarzi
UKACM 2017 Conference Chairman
University of Birmingham

China Friendship Award:
Professor Roger Owen FRS FREng

Professor D. Roger J. Owen, a Research Professor in the Zienkiewicz Centre for Computational Engineering at Swansea University, UK and member of the IACM General Council has been presented with the 2016 Friendship Award, which is the People's Republic of China highest award for "foreign experts who have made outstanding contributions to the country's economic and social progress". The winners are selected by the State Administration of Foreign Experts Affairs (SAFEA) under the State Council and the award was conferred as part of the celebrations for the National Day of the People's Republic of China. The award comprised a medal and an award certificate. The award was presented by Ma Kai, who is one of the four Vice Premiers of China. This was followed by an invitation to a National Banquet by President Xi JinPing and Premier Li Keqiang, the current Premier of the State Council of the People's Republic of China, which was held in the Great Hall of the People.

Professor Owen has been honoured for his involvement with China in R&D activities for over 30 years, particularly in the area of the finite element method which is acknowledged as the most powerful computational procedure to emerge for the solution of a wide range of engineering and scientific problems over the last fifty years. As readers will know, Swansea University has been a world leader in the development and application of such computational methods over the last five decades. This was quickly recognised by the Chinese scientific community and Swansea has hosted a stream of Chinese students and research visitors from the mid 1970s to the present day. Professor Owen has personally supervised more than 15 Ph.D. students and over 20 postdocs and visitors from China. Three of his textbooks have been translated into Chinese, which has provided the basis for research students and scientific researchers to develop their own research codes to be used for both fundamental studies and practical applications. Their influence can still be seen in many of the codes found in the Chinese research community today.

Through these activities, Professor Owen has developed strong links with many of the leading Chinese universities and research institutions; in particular with Tsinghua University and also the Chinese Academy of Sciences. His position as a Fellow of the Royal Society and Royal Academy of Engineering, UK has enabled him to initiate a variety of activities, including a series of Swansea-Tsinghua workshops on computational mechanics, a range of collaborative UK/EU/China funded research projects, participation in a major '973' research project on Numerical Techniques for Severe Engineering Induced Geological Disasters and the establishment of a joint research laboratory for Discontinuum Mechanics for Engineering Disasters (DMED),between Swansea and the Institute of Mechanics, Chinese Academy of Sciences. Professor Owen's standing in the Chinese scientific community has led to his election as Foreign Member of the Chinese Academy of Sciences in 2011.

Professor Owen said: "I am deeply honoured to have been selected to receive the Friendship Award from the government of China. It has been a privilege to work with so many talented research colleagues and students from China, which has proved to be an extremely rewarding experience". ●

" ... a privilege to work with so many talented ... colleagues ... which has proved to be an extremely rewarding experience."

APMTAC

The Portuguese Association for Theoretical, Applied and Computational Mechanics

IACM O.C. Zienkiewicz award presented to Carlos Mota Soares

Professor **Carlos Mota Soares**, who has been until last year, and for almost two decades, the **President of APMTAC**-The Portuguese Association for Theoretical, Applied and Computational Mechanics has received the **IACM O.C. Zienkiewicz Award,** given in recognition of outstanding and sustained contributions to the broad field of computational mechanics.

The award was presented during WCCM XII, the 12th World Congress on Computational Mechanics, held in July 2016, in Seoul, South Korea. This distinction rightly crowns a brilliant career dedicated to Computational Mechanics and much honours the Portuguese community in this scientific area and in particular the APMTAC.

Professor Carlos Mota Soares, who has recently retired from University of Lisbon, has also recently been awarded the **Doctor "Honoris Causa"** Degree from the University of Porto, in April 2017, to distinguish his exceptionally contribution to scientific development in Mechanical Engineering, in particular in Computational Mechanics, his spirit of mission and vision for the country and society at large.

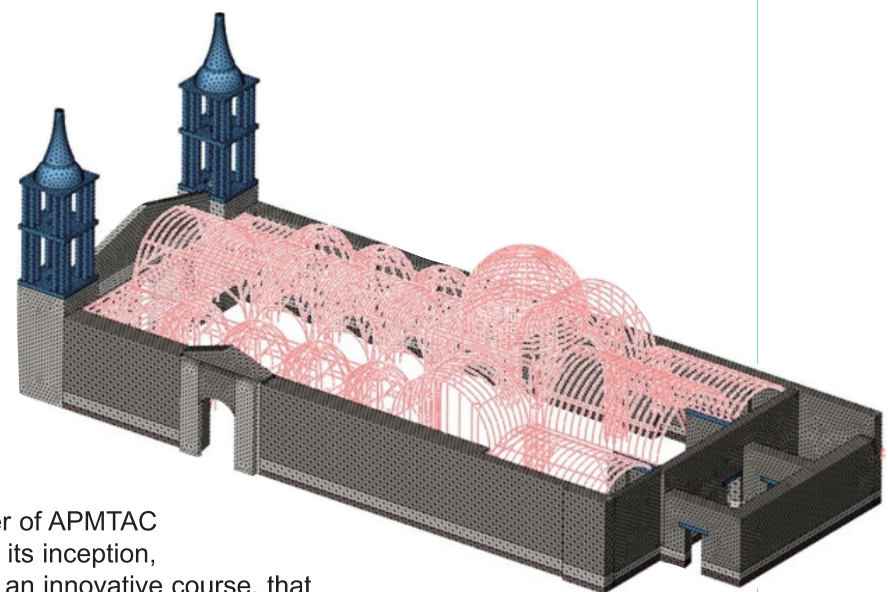
Professor Mota Soares is now the President of the General Assembly of APMTAC.

APMTAC, through its members and its institutional support, has been and is very active in the promotion of Computational Mechanics both in the organization of several congresses or conferences and in the development of university academic courses.

In 2017 the following conferences take place in Portugal:

- **SYMCOMP 2017 - 3rd International Conference on Numerical and Symbolic Computation Developments and Applications**
  Guimarães, Minho, Portugal, 6-7 April 2017, http://symcomp2017.dem.isel.pt/index.htm. This conference aims establish the state of the art and present innovative applications and guidelines on the use of Numerical and Symbolic Computation in the numerous fields of knowledge, such as Engineering, Physics, Mathematics, Economy and Management, Architecture…

- **VipIMAGE2017- Conference on Computational Vision and Medical Image Processing**
  18-20 October 2017 ,Porto, Portugal, https://paginas.fe.up.pt/~vipimage/index.html. This conference focuses on Computational methodologies of signal processing and analyses, namely considering 2D, 3D and 4D images, that are commonly used in



The Advanced Master in Structural Analysis of Monuments and Historical Constructions (SAHC, http://msc-sahc.org/) is a one-year Master programme, coordinated by University of Minho, Portugal, that just received the **Europa Nostra Award 2017** in Category Education, Training and Awareness-Raising.

Prof Paulo Lourenço, a member of APMTAC managing board, has been, from its inception, in the forefront of this successful an innovative course, that uses computational mechanics as an important tool. This initiative offers an advanced education programme on the conservation of cultural heritage structures, focusing on the application of scientific principles and methodologies in analysis, innovation and practice.

Established in 2007, 350 students from 65 countries have so far partaken in the programme. ●

CMN 2017 - CMN-Numerical Methods in engineering

In 3-5 July, http://congress.cimne.com/CMN2017/frontal/default.asp, which is biennial and jointly organized by the Spanish Society of Numerical Methods in Engineering (SEMNI) and the Portuguese Association for Theoretical, Applied and Computational Mechanics(APMTAC) will be held in Valencia, Spain. CMN 2017 will be a meeting point for researchers and technicians of the two countries, as well as the Latin American community. ●

different applications of our society. A special view on applications in the medical area will be addressed, in which the use of statistical or physical procedures on medical images, in order to model the images structures, have important applications on shape reconstruction, organs identification, multimodality data registration, behavior simulation, motion and deformation analysis, virtual reality, computer-assisted therapy or tissue characterization.

- **Computational Modelling of Multi-Uncertainty and Multi-Scale Problems**
  12-14 September, Porto, Portugal, https://comus17.com/. This conference focuses on the development of multi-uncertainty and multi-scale models that have played a central role in the understanding of the interaction among multi-physics and multi-uncertainty phenomena taking place at multiple scales in space and time.
  The main aims of the Comus 17 are too present the state-of-the-art in this field by showing the most recent developments by leading experts, and to provide a forum for discussion of current research trends and future challenges in computational multi-uncertainty and multi-scale modelling. ●

Argentine Association for Computational Mechanics

In Memoriam

Gustavo Sanchez Sarmiento

Jan 10, 1947 – Dec 16, 2016

On Friday December 16th 2016, a few minutes before the Instituto Balseiro´s (IB) annual graduation ceremony, we were told that our friend Gustavo Sánchez Sarmiento had passed away. There was no information on the circumstances of his death. Some days later we knew that he had suffered a heart attack while coming back home from a piano lesson.

Gustavo was a pioneer in Computational Mechanics in Argentina when numerical methods just made their appearance in engineering, being one of the founding members of the Argentine Association for Computational Mechanics (AMCA) in 1985.

He was a key piece in the generation of what today is our Computational Mechanics Department of the CAB's Applied Research, along with Fernando Basombrío, Sergio Pissanetzky and Bibiana Cruz. These were the times when our Computer Center had an IBM 360 with a card reader and the domain discretization needed for our simulations was made by hand, with paper and pencil.

Gustavo studied Physics at Instituto Balseiro (IB), where he graduated first as Bachelor in Physics (IB 1973) and later as doctor in Nuclear Engineering (IB 1996). He was a researcher of CNEA and teacher at IB between 1974 and 1981. He also served as head of the Department of Computational Mechanics at ENACE between 1981 and 1987 and as head of the Department of Physics of the School of Engineering of UBA between 1993 and 1996. As a private consultant, Gustavo founded and served as CEO of KB Argentina SRL.

He taught 56 postgraduate courses and gave 62 invited talks in conferences in several countries. He is the author of more than 100 articles in scientific journals, 370 technical reports and 250 conference papers. In 1986 Gustavo received the First National Engineering Award from the Argentine Ministry of Education. In 2002 he won the Argentine Association of Computational Mechanics Award for senior researchers. In 2014 he received the Recognition Prize of the National Academy of Sciences of Buenos Aires.

Gustavo was a brilliant researcher, a promoter of computational methods in engineering and a necessary reference for computational mechanics researchers. He had a strong teaching

ENIEF 2017 - XXIII Congress on Numerical Methods and their Applications

La Plata, Buenos Aires, Argentina
7-10 November 2017

The Argentine Association for Computational Mechanics (AMCA) announces the XXIII Congress on Numerical Methods and their Applications, which will be held at La Plata,

Figure 1:
Gustavo Sanchez Sarmiento participating at ENIEF 2016

vocation and was a fair colleague always ready to share his knowledge with us.

He visited CAB-IB whenever an event called him for. He was a regular assistant to the ENIEF and MECOM conferences, where he was highly recognized.

Gustavo was a very warm and cordial person and he was especially sociable at meetings. At the last ENIEF congress that we organized in Bariloche in 2014 he entertained us all during the conference dinner by singing some tangos and opera areas with great talent.

We join his family and colleagues in saying good bye to a good friend. ●

Computational Mechanics Department
CAB

Acronyms

IB Instituto Balseiro
CAB Centro Atómico Bariloche
CNEA Comisión Nacional de Energía Atómica
UBA University of Buenos Aires
ENACE Empresa Nuclear Argentina de Centrales Eléctricas

Buenos Aires, Argentina, organized by the Faculty of Engineering of the National University of La Plata.

Confirmed Plenary Speakers:

Sergio R. Idelsohn
CIMNE, Barcelona, Spain.

Rainald Löhner
George Mason University, Fairfax VA, USA.

Julián J. Rimoli
Georgia Institute of Technology, Atlanta, USA.

Oscar Lopez-Pamies
University of Illinois at Urbana-Champaign.

Jaime Klapp
ININ, Mexico.

Alejandro D. Otero
Facultad de Ingeniería, Universidad de Buenos Aires, Argentina ●

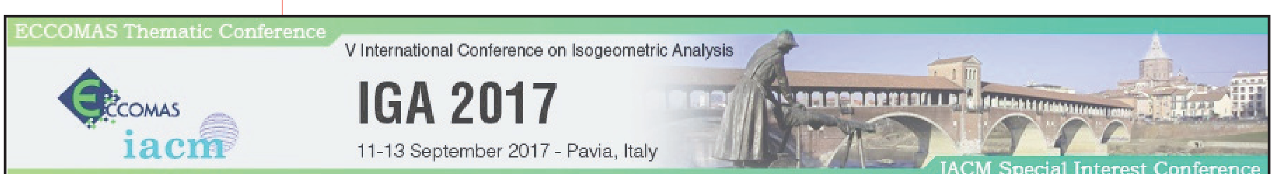
(IGA 2017)
Fifth International Conference on Isogeometric Analysis

The Fifth International Conference on Isogeometric Analysis (IGA 2017) will be organized in Pavia, Italy, on **11-13 September 2017**. The first and the second conference of this series were held in Austin (Texas), United States, on 13-15 January 2011 and 8-10 January 2014, the third was held in Norway on 1-3 June 2015, the fourth in La Jolla, California, United States on October 10-12, 2016.

The objective of IGA 2017 is to be a meeting place for researchers developing computational methods and scientists and engineers focusing on using Isogeometric methods for addressing challenging applications in science and engineering.

The conference is one of the Thematic Conferences of the European Community on Computational Methods in Applied Sciences (ECCOMAS) and one of the Special Interest Conferences of the International Association for Computational Mechanics (IACM).

Further information may be found at: http://congress.cimne.com/iga2017

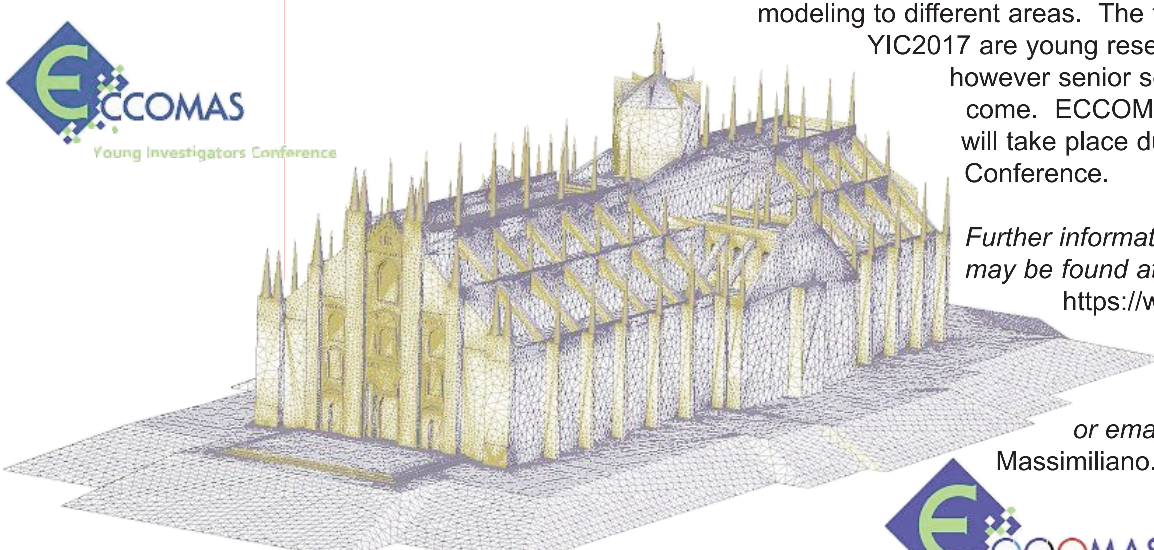


ECCOMAS Young Investigators Conference 2017

The **4th ECCOMAS Young Investigators Conference (YIC2017)** will take place from **September 13rd through 15th, 2017** at Politecnico di Milano, Italy.

The conference aims to bring together young researchers working in the field of computational science and engineering. As in the previous conferences organized under the auspices of the European Community on Computational Methods in Applied Sciences (ECCOMAS), the focus is on the application of computational methods and modeling to different areas. The target group of the YIC2017 are young researchers however senior scientists are wel come. ECCOMAS PhD Olympiad will take place during the Conference.

ECCOMAS Young Investigators Conference



Further information may be found at: https://www.eko.polimi.it/index.php/YIC2017/conf

or email: Massimiliano.cremonesi@polimi.it

ECCOMAS PHD OLYMPIAD

Annual Meeting of ESB-ITA

The Annual Meeting of the **Italian Chapter of the European Society of Biomechanics (ESB-ITA)** will be held in Rome, Italy, on **28-29 September 2017**. The meeting foresees a two-day programme. The first day hosts the Second edition of the ESB-ITA Thematic Symposium which deals with the biomechanics of eye; the goal of the symposium organised by Anna Pandolfi (Politecnico di Milano) aims at integrating approaches and ideas between physicians and engineers about a specific thematic, i.e., the eye and its tissue. The second day hosts the general assembly of the ESB-ITA, aiming at presenting a broad scientific overview of the biomechanical activities of the Italian labs, supporting the networking among the members of the biomechanical community in Italy and abroad. The organization of the event is supported by Giuseppe Vairo (University of Roma Tor Vergata).

Further information may be found at:

http://www.esb-ita.it/main/meetings/esb-ita17-%C2%A6-home/

or email:
meeting@esb-ita.it

5th International Conference on Computational Contact Mechanics

Previous meetings in the ICCCM series were held in Lecce (2009 and 2013) and Hannover (2011 and 2015). All these meetings have been very successful and, together with the next one, they are becoming an established event in the field of Contact Mechanics.

The aim of the Conference is to provide an international forum for researchers, practitioners and for all the scientists who are concerned with modern computational techniques and applications in the field.

Further information may be found at:
http://icccm2017.unisalento.it

Minisymposium GIMC

(Italian Group of Computational Mechanics):
Novel Approaches in Computational Mechanics

In the XXIII AIMETA Congress
(Italian Association of Theoretical and Applied Mechanics)

UNIVERSITY OF SALERNO
4-7 September, 2017
Salerno, ITALY ●

SEMNI & CSMA

joint Spanish-French workshop on computational mechanics

SEMNI and CSMA celebrated their 3rd joint Spanish-French workshop on computational mechanics.

This joint workshop has been held on a biannual basis since 2013, when its first edition took place in Jaca, Spain, in the Pyrenees. Since then, a second edition took place in Biarritz, France, in 2015. This year, we came back to Jaca, to the Residence of the University of Zaragoza, were a total of 35 people met together to strengthen the links between both associations.

This year's workshop was devoted to the general topic of "Numerical techniques for nowadays highly computationally demanding challenges: meshless, Model Order Reduction and beyond". We also took the opportunity to celebrate a symposium on the honor of prof. Pierre Villon, one of the pioneers of meshless methods, on the occasion of his retirement (although he is now emeritus professor and will be among us for many years to come!)

Figure 1:
A group picture during the workshop

SEMNI renewed its Executive Committee

Last October 2016, SEMNI renewed its executive board.
As a result of the bi-annual elections, the following members members entered the board:

Irene Arias (Universitat Politècnica de Catalunya)
Joan Baiges (CIMNE)
Ignasi Colominas (Universidade da Coruña)
Antonio Huerta (Universitat Politècnica de Catalunya)
Fermín Navarrina (Universidade da Coruña)
Ignacio Romero (Universidad Poiltécnica de Madrid)

In a meeting held in November, Prof. Elías Cueto, from the University of Zaragoza, was elected as the new president, thus substituting Prof. Xavier Oliver, who acted as president

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ecueto@unizar.es

Figure 2:
A view of the room during a break on the lectures

Figure 3:
Prof. Villon giving the speech during the gala dinner

The workshop demonstrated that both the Spanish and French communities share interests and that they enjoy meeting and sharing three days of fruitful discussions. These small workshops constitute a unique opportunity to analyse in detail those aspects of our research that are usually not covered in standard conferences, due to the lack of time.

We look forward to meeting again in 2019!

Figure 4:
SEMNI executive board

during the last eight years. Prof. Goicolea (Polytechnic University of Madrid) continues to serve as vice-president, while Prof. Irene Arias (Polytechnic University of Catalonia) continues as secretary general.

JACM 日本計算力学連合

Japan Association for Computational Mechanics

For all inclusions under
***JACM** news*
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jacm-jim@save.sys.t.u-tokyo.ac.jp

The JACM is a union of researchers and engineers working in the field of computational mechanics mainly in Japan. JACM is a loosely coupled umbrella organization covering 29 computational mechanics related societies in Japan through communication with e-mail and web page (http://www.sim.gsic.titech.ac.jp/jacm/index-e.html). The number of individual members is about 310.

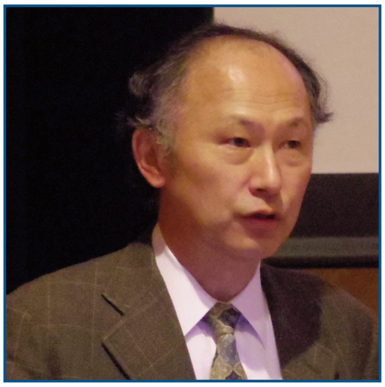


Figure 1:
Professor Shinobu Yoshimura chairing the symposium

Figure 2:
Professor Genki Yagawa making the opening remarks

JACM participated the Sixth Computational Mechanics Symposium held on December 5, 2016. The symposium is organized by the Science Council of Japan (SCJ) in association with eight computational mechanics related societies.

The SCJ was established in 1949 as a “special organization” under the justification of the Prime Minister, operating independently of the government for the purpose of promoting and enhancing the field of science, and having science reflected in and permeated in administration, industries and people’s lives. It represents Japan’s scientists both domestically and internationally … (http://www.scj.go.jp/en/scj/index.html). The annual SCJ Computational Mechanics Symposium has become a new tradition and is an evidence of how Japanese science and engineering community finds computational mechanics to be a very important area.

In the sixth symposium, eight young researchers representing the participating computational mechanics related societies presented their latest research outcomes. They are recent recipients of Young Investigators Award of each society. Professor Yuki Onishi of Tokyo Institute of Technology participated the symposium as one of the recipients of 2016 JACM Young Investigator Award.

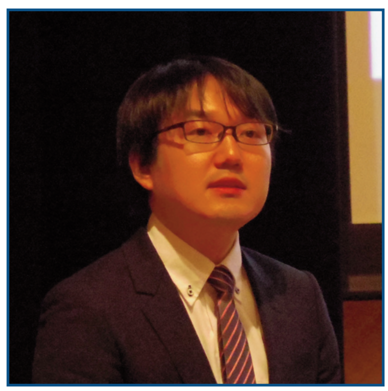
The other societies participated are:
“Japan Society for Computational Methods in Engineering (JASCOME)”, “CAE Konwakai”, “The Computational Mechanics Division of The Japan Society of Mechanical Engineers (CMD, JSME)”, “Japan Society for Computational Engineering and Science (JSCES)”, “The Japan Society for Simulation Technology (JSST)”, “The Visualization Society of Japan (VSJ)” and “The Japan Society for Industrial and Applied Mathematics (JSIAM)”.

Professor Shinobu Yoshimura (SCJ Adjunct Member, President of JACM) chaired the symposium this time. After his opening address, Professor Genki Yagawa (SCJ Adjunct Member, Former President of IACM) gave opening remarks. Then, presentations by eight young researchers followed (They are listed in order):

- Professor Dai Okumura (JASCOME, Osaka University) on the swelling-induced instability of hydrogel
- Dr. Masato Naito (CAE Konwakai, Sumitomo Rubber Industries Ltd.) on multi-scale simulation for the development of next generation high performance tires

- Professor Takayuki Yamada (CMD, JSME, Kyoto University) on the latest developments in the topology optimization
- Professor Junji Kato (JSCES, Tohoku University) on multi-scale topology optimization and additive manufacturing processes
- Professor Yuki Onishi (JACM, Tokyo Institute of Technology) on finite deformation analysis using the SFEM (Smoothed Finite Element Method)
- Dr. Kazuya Goto (JSST, PExProCS) on multiple constraint technique for large-scale finite element analysis on an assembled structure
- Dr. Sayaka Yagi (VSJ, Nippon Telegraph and Telephone Corporation) on the storyline-based visualization of consecutive numerical time-varying data
- Professor Akitoshi Takayasu (JSIAM, University of Tsukuba) on the numerical validation of blow-up solutions of ordinary differential equations

After those presentations, a panel discussion on "A point of reference in curriculum- design/development for disciplinary quality assurance in university education" for the field of computational mechanics was carried out. " A point of reference in curriculum" is the series of the guidelines made by SCJ for designing university education programs in each discipline, such as mechanical engineering, civil engineering, physics, etc. In the panel discussion, the draft for the field of computational mechanics under development was explained by Professor Ichiro Hagiwara (SCJ Adjunct Member, Meiji University) first and discussions on computational mechanics education followed. The symposium ended by the closing remark of Professor Hagiwara. "A point of reference in curriculum" for the field of computational mechanics is to be issued this summer after a review process in SCJ. ●



Figures 3:
Professor Yuki Onishi (Tokyo Institute of Technology) during his presentation

Figures 4:
Professor Takyuki Yamada (Kyoto University) in the discussion after his presentation

Figures 5:
Participants of the symposium

The JSCES General Assembly Meeting and Special Symposium

The eighth assembly meeting of JSCES was held at the Ito International Research Center, the University of Tokyo, Japan, on May 19th, 2017. Both the operating and financial review for the previous fiscal year and operation and financial plan for this fiscal year were reported in this meeting *(Figure 1)*. The general assembly meeting was followed by the JSCES special symposium, in which a lecture was given by Dr. Yuzo Ohnishi, the Professor Emeritus of Kyoto University. He delivered a talk entitled "Looking Back at the Role of Computational Mechanics Contributed in Development of Soil and Rock Engineering". He explained a brief history of rigid bodies – spring model (RBSM), discrete element method (DEM), discontinuous deformation analysis (DDA), numerical manifold method (NMM) and particle methods (MPS, SPH), and their applications in coupled problems of thermal, humid, mechanical and chemical (THMD) phenomena *(Figure 2)*.

Figure 1: *General assembly meeting*

Figure 2: *Prof. Yuzo Ohnishi*

Award Ceremony for JSCES Prizes

On the same day, JSCES prizes were offered to senior and young researchers and practitioners. This year's recipients were: Prof. Yutaka Toi (The JSCES Achievements Award), Dr. Ryutaro Himeno (The JSCES Achievements Award), Prof. Ryuji Shioya (Kawai Medal), Dr. Hideyuki Sakurai (Shoji Medal), Mr. Atsushi Kikuchi (The JSCES Merit Award), and Mr. Masaru Tateishi (Technology Prize). Paper awards associated with the Transaction of the JSCES (see, https://www.jstage.jst.go.jp/browse/jsces) were also given to the following researchers: Prof. Takuya Matsunaga, Prof. Kazuya Shibata, Dr. Kohei Murotani and Prof. Seiichi Koshizuka (Outstanding Paper Award), Prof. Yuichi Shintaku (Outstanding Paper Award), Prof. Masao Ogino (Young Researcher Paper Award), Ms. Xi Chen (Young Researcher Paper Award). Moreover, Prof. Fumio Kikuchi was awarded as an honorary member, and Dr. Takaya Kobayashi and Dr. Naoya Sasaki were awarded as fellow members *(Figure 3)*.

Figure 3: *Group shot of the recipients of the JSCES Awards: (back row) Ms. X. Chen, Prof. M. Ogino, Prof. Y. Shintaku, Prof. S. Koshizuka, Prof. T. Matsunaga (front row) Prof. R. Shioya Mr. M. Tateishi, Dr. R. Himeno, Dr. M. Shoji, President K. Terada, Prof. F. Kikuchi, Dr. H. Sakurai, Mr. A. Kikuchi, Dr. N. Sasaki*

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Annual Conference

The 22nd JSCES's Annual Conference on Computational Engineering and Science, chaired by Prof. S. Okazawa (Univ. Yamanashi), was held during May 31 – June 2, 2017, at the Sonic City hall (Omiya, Japan). The conference was attended by about 600 participants, and over 380 papers with full lectures were presented by researchers, graduate students and practitioners. Fruitful discussions were exchanged in 30 organized sessions associated with a plenary lecture, a special event for young engineers, graphic awards and six luncheon seminars.

On the second day of the conference, a plenary lecture entitled "Innovative Computational Technologies for Challenging Engineering Problems" was given by Prof. Charbel Farhat of Stanford University, USA. In his lecture, he presented a progress report on the real-time solution of complex, parametric engineering problems in aeronautics, automotive, and naval engineering using Hyperreduced, Projection-based Reduced-Order Models (HPROMs). Then, a nonparametric probabilistic approach for modeling form uncertainties in a nonlinear HPROM and quantifying uncertainties in its associated high-dimensional counterpart was explained. Other innovative ideas were demonstrated, in his lecture, through the solution of several realistic problems in computational analysis and design. Prof. Farhat received "The JSCES Grand Prize 2017", for his outstanding contributions in the field of computational engineering and sciences, at the following ceremony *(Figure 4)*. An award ceremony for the JSCES scholarship award was also held, and the awards were presented to Prof. Takeki Yamamoto (Tohoku Univ.) and Prof. Yuichi Shintaku (Univ. of Tsukuba) *(Figure 5)*. ●

Figure 4:
Prof. Charbel Farhat receiving the JSCES Grand Prize

Figure 5:
Prof. T. Yamamoto (left) and Prof. Y. Shintaku (right) with President K. Terada

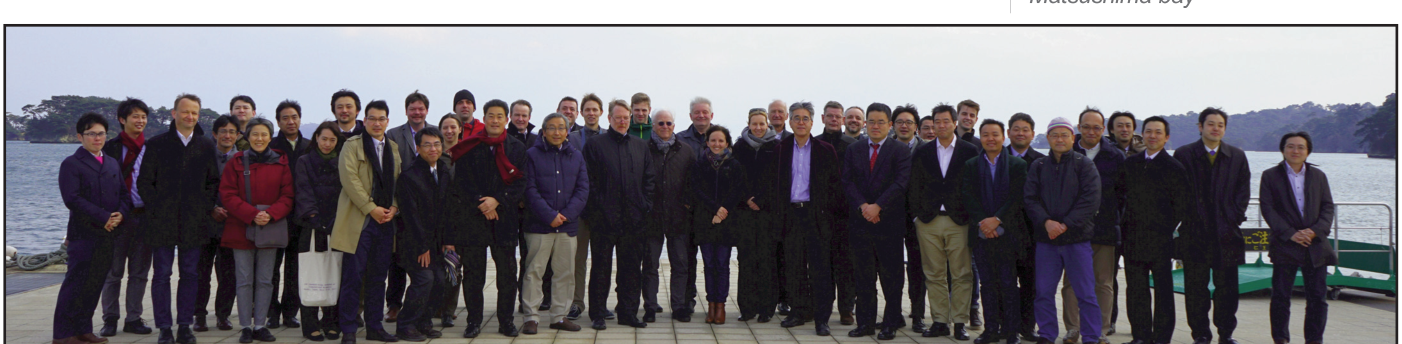
The 4th Japanese-German Workshop on Computational Mechanics

The 4th Japanese-German Workshop on Computational Mechanics (4JG) organized by the JSCES and the German Association for Computational Mechanics (GACM) was held during March 27-28, 2017, at Tohoku Forum for Creativity in Tohoku University and Hotel Matsushima Taikanso, located at beautiful sea coast area of Matsushima. The aim of this workshop series is to intensify the scientific relationship between senior and junior German and Japanese researchers in the broad field of computational mechanics. Two keynote lectures and 18 general talks from both countries were delivered and fruitful discussions were exchanged even at the traditional Japanese banquet after the session. The participants from both countries also enjoyed the scenic view of hundreds of islands, located offshore of Matsushima bay in the excursion *(Figures 6, 7 & 8)*. ●

Figure 6:
Audience concentrating on a presentation

Figure 7:
Prof. M. Kaliske and Prof. S. Klinkel enjoying the scenic view of Matsushima

Figure 8:
A group shot in front of Matsushima bay



Two Priority Programmes Related to GACM
By the German Research Foundation (DFG)

"A particular feature of the Priority Programme is the nationwide collaboration between its partici-pating researchers. The DFG Senate may establish Priority Programmes when the coordinated support given to the area in question promises to produce particular scientific gain. As a rule, Priority Programmes receive funding for a period of six years." [http://www.dfg.de/en]

SPP 1748: Reliable Simulation Techniques in Solid Mechanics - Development of Non-Standard Dis-cretisation Methods, Mechanical and Mathematical Analysis

The Priority Programme SPP 1748 was established in autumn 2014 with overall eleven research pro-jects. A specific characteristic of the Priority Programme is the joint collaboration between mechanics and mathematics not only in the Programme itself but also in nearly all projects. The main intention of SPP 1748 is the development of novel numerical simulation techniques, which are nowadays an essential component for the construction, design and optimisation of cutting-edge technologies. The developments in many practical computational engineering applications pose great demands on quality, reliability and capability of the applied numerical methods. Challenges are, for example, cap-ture of incompressibility, anisotropy and discontinuities. Existing computer-based solution methods often provide approximations, which cannot guarantee substantial and necessary stability criteria and fulfil them, respectively. Especially in the field of geometrical and materi-al non-linearity such uncertainties appear. Typical problems are insufficient or even pathological stress approximations due to unsuitable approximation spaces as well as weak convergence behaviour because of stiffening effects or mesh distortion. Similar problems arise in the framework of crack and contact problems. Here, the resolution of the local discontinuities as well as their evolution plays a key role. The scientists of the Priority Programme have set themselves the goal to establish a new quality in the area of non-conventional discretisation methods. Herein, the work programme of the Priority Programme is founded: (1) the construction of modern non-conventional discretisation methods, (2) their mathe-matical analysis, and (3) the exploration of their application limits on the basis of suitable defined SPP benchmark problems.

Coordinator: **Prof. Jörg Schröder,** Essen
Homepage: **www.uni-due.de/spp1748/**
ECCOMAS Thematic Conference on 'Modern Finite Element Technologies - mathematical and me-chanical aspects': **www.mfet2017.de**

The 7th GACM Colloquium on Computational Mechanics

The 7th GACM Colloquium on Computational Mechanics (GACM 2017) will be organized in **Stuttgart, Germany** from **October 11-13, 2017**. The colloquium is hosted by the Institute of Structural Mechanics and the Institute of Applied Mechanics of the University of Stuttgart in collaboration with DYNAmore GmbH. The previous six conferences of this series were held in Bochum (2005), Munich (2007), Hannover (2009), Dresden (2011), Hamburg (2013) and Aachen (2015).

The GACM Colloquium on Computational Mechanics (**www.gacm2017.uni-stuttgart.de**) intends to bring together young scientists who are engaged in academic and industrial research on Computational Mechanics and Computer Methods in Applied Sciences. It provides a platform to present and discuss recent results from research efforts and industrial applications.

SPP 1886: Polymorphic Uncertainty Modelling for Numerical Design or Structures

The German Research Foundation has approved a new Priority Program (SPP 1886) with a budget of 11.3 million € for 6 years. Since January 2017, 10 German universities in five thematic complexes cooperate very closely within the framework of 22 subprojects.

Numerical design of structures should be robust with respect to uncertainties inherently present in resistance of materials, boundary conditions e.g. environmental and man imposed loads, physical and numerical models. This requires in turn the availability of a reliable numerical analysis, assessment and prediction of the lifecycle of a structure taking explicitly into account the effect of the unavoidable uncertainties. Challenges in this context involve, e.g., limited information, human factors, subjectivity and experience, linguistic assessments, imprecise measurements, dubious information, unclear physics etc. Due to the polymorphic nature and characteristics of the available information both probabilistic and set-theoretical approaches are relevant for solutions.

The Priority Program 1886 aims at bringing together researchers, academics and practicing engineers concerned with the various forms of advanced engineering designs. Recent developments of numerical methods in the field of engineering design, which include a comprehensive consideration of uncertainty and associated efficient analysis techniques, such as advanced Monte Carlo simulation, meta-model approximations, and High Performance Computing strategies are addressed. These may involve imprecise probabilities, interval methods, Fuzzy methods, and further concepts. The Priority Program 1886 may address specific technical or mathematical details, conceptual developments and solution strategies, individual solutions, and may also provide overviews and comparative studies. Particular attention should be paid to practical applicability in engineering.

Coordinator: **Prof. Michael Kaliske**, Dresden
Homepage: **www.tu-dresden.de/spp1886**

(GACM 2017)

Thematically arranged sessions and organized mini-symposia as well as social events will provide an environment for lively discussions in an informal atmosphere. The contributions from young researchers will be supplemented by plenary lectures from three senior scientist from academia and industry as well as from the GACM Best PhD Award winners 2015 and 2016. In addition, there will be a poster session including a plenary poster-flash. All submitted posters are eligible for the GACM Best Poster Award.

We are looking forward to welcome you in Stuttgart!

Malte von Scheven, Marc-André Keip and Nils Karajan
(Conference Chairmen)

Advances in Computational Science and Engineering, in honor of the 80th birthday of Professor J. Tinsley Oden

March 20-21, 2017; Austin, Texas

In March 20-21, 2017 the U.S. Association for Computational Mechanics and ICES hosted the international conference "Advances in Computational Sciences and Engineering" to honor Professor J. Tinsley Oden's 80th birthday and the achievements of his long and productive career.

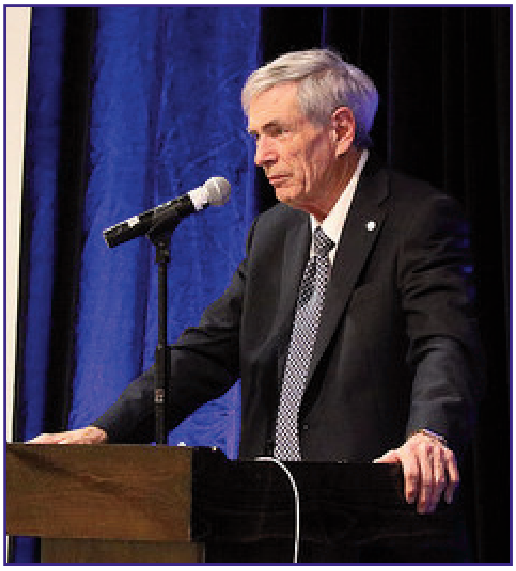


Figure 1:
Prof. J. Tinsley Oden speaks at dinner in honor of his 80th birthday

Oden, a major player in the development and global acceptance of computational mechanics, has been recognized throughout the world from his Knighthood in France to five honorary doctorates to the Honda Prize Laureate in 2013 and is one of the founding members of IACM and former President of the Association. He has been a tireless promoter of Computational Engineering and Sciences, the "third pillar of science."

Attended by former graduate and post-doctoral students as well as long-term colleagues and close friends, the conference consisted of 12 talks and 2 poster sessions with a total of 35 posters. The highlight of the conference was a dinner held in Prof. Oden's honor, celebrating his many contributions and highlighting his extraordinary accomplishments in the field of computational mechanics.

Figure 2:
Prof. Oden discussing poster with presenter

The event was organized by Drs. Leszek Demkowicz, Jon Bass, Yusheng Feng, Patrick LeTallec, Serge Prudhomme, J.N. Reddy, Theofanis Strouboulis, and Tarek Zohdi. It was held as part of the USACM TTA on Mathematical Methods in Computational Engineering and Sciences. ●

Figure 3:
Attendees at conference in honor of Professor J. Tinsley Oden's 80th birthday

USACM Upcoming Events - further details at usacm.org/conferences

- **14th U.S. National Congress on Computational Mechanics,** July 17-20, 2017, Montreal, Canada, http://14.usnccm.org/
- **Advances in Integrated Computational and Experimental Methods for Additive Manufacturing,** September 6-8, 2017, Golden, CO, http://aicem-am2017.usacm.org/ (TTA on Manufacturing and Materials Processing)
- **Residual and Least Squares Finite Element Methods,** October 2-7, 2017, Portland, https://sites.google.com/pdx.edu/dpg/home (TTA on Mathematical Methods in Computational Engineering & Science),
- **Nonlocal Methods in Fracture ,** January 15-16, 2018, Austin, TX, http://nmf2018.usacm.org/ (TTA on Novel Methods in Computational Engineering & Sciences) ●

USACM Thematic Workshop on

Uncertainty Quantification and Data-Driven Modeling

March 23-24, 2017; Austin, TX

Organized as part of the USACM Technical Thrust Area (TTA) on Uncertainty Quantification and Probabilistic Analysis, the purpose of this Workshop on Uncertainty Quantification and Data Driven Modeling (http://uqpm2017.usacm.org/) was to bring together leading experts in uncertainty quantification, statistics, computer science, and computational science to discuss new research ideas in data-driving modeling. With UQ now established as a core area of computational science and engineering, data science is quickly emerging as a critical accompanying technology area for enabling validated, predictive simulations. However, data science is still in its infancy and new ideas are needed, especially in the context of UQ for multi-scale, multi-physics science and engineering applications.

Through this workshop, we highlighted new advances in UQ and data-driven modeling that will lead to breakthroughs in our ability to develop predictive models for realistic applications.

Areas of interest included,

- Deterministic and stochastic inverse problems
- Data assimilation methodologies, particularly in the context of datasets with a high degree of noise and/or poorly characterized uncertainties
- Machine learning and data mining methods to inform model development
- Inference of models, including parameters and functional forms
- Validation and data-informed predictions for science and engineering applications
- Uncertainty quantification for large-scale, high-dimensional problems

The organizers of the workshop were James R. Stewart (Sandia National Laboratories) and Krishna Garikipati (University of Michigan). A total of 90 people registered for the well-attended the workshop. The photo below shows the workshop venue at capacity. The workshop format consisted of 20 talks (25 minutes each) organized over six sessions, as well as 34 posters organized into one poster session. The poster session started with a lively one-minute poster introduction by each of the poster presenters. ●

Figure 5:
Well attended conference on Uncertainty Quantification & Data-Driven Modeling

French Comutational Structural Mechanics Association

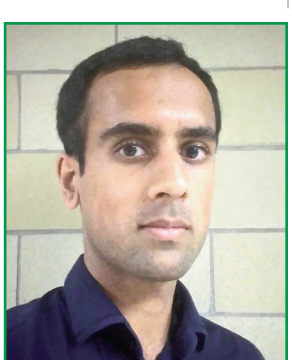
CSMA Prizes: Every year CSMA rewards the best two PhD thesis of the year. For the 2016 edition, the CSMA prize committee has examined 13 applications. The two awardees are Modesar Shakoor and Alessandro Cattabiani. Modesar Shakoor is designated as the CSMA candidate for the ECCOMAS award for the best PhD theses in 2016.

for all inclusions under ***CSMA*** *please contact*
Francisco Chinesta
Francisco.Chinesta@ec-nantes.fr

Alessandro Cattabiani: Simulation of low- and medium-frequency impact response using a Frequency Approach.
Advisors: Pierre Ladevèze, Hervé Riou (LMT, ENS Cachan)

The mid-frequency range still poses major difficulties to commercial shock-propagation codes. The software developed in the context of this thesis, is based on the Variational Theory of Complex Rays (VTCR) which is a frequency-based Trefftz method specifically developed to analyze the midfrequency band. Many theoretical and performance improvements are introduced to address real industrial test cases. The goal of the PhD is to develop an approach combining numerical simulations and experimental techniques to model complex microcracking in heterogeneous cementitious materials. The proposed numerical model allows ¬¬¬¬ predicting accurately in 3D the initiation and the propagation of microcracks at the scale of the actual microstructure of a real sample subjected to compression. Its predictions have been validated by a direct comparison with the actual crack network characterized by 3D imaging techniques. The phase-field method is applied to microcracking simulations in highly heterogeneous microstructures and its advantages for such simulations are discussed. Then, the technique is extended to account for interfacial cracking, possibly occurring at inclusion/matrix interfaces. In a second part, the procedures to obtain the evolution of the 3D crack network within the samples by means of X-rays computed microtomography and in-situ mechanical testing are presented. The developed image processing tools based on digital volume correlation are used to extract with good accuracy the cracks from the grey level images. In a third part, are compared the predictions of the numerical model with experimental results, first, with a model material made of expanded polystyrene beads embedded in a plaster matrix, and second, to a more complex lightweight concrete.
Current situation: Allessandro holds a Post-Doc Fellow position at Technical University of Munich - Germany and he works on Simulation and Study of the Additive Manufacturing Process.

Modesar SHAKOOR: Three-dimensional numerical modeling of ductile fracture mechanisms at the microscale
Advisors: Pierre-Olivier Bouchard, Marc Bernacki, Center for Materials Forming, Mines ParisTech



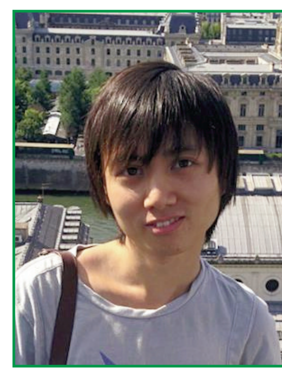
The thesis aims at a better understanding and modeling of ductile fracture during the forming of metallic materials typically formed using series of thermomechanical loads where many parameters such as loading type and direction vary. Ductile fracture in metallic materials is the result of a progressive deterioration of their load carrying capacity due to the nucleation, growth, and coalescence of microscopic voids. In this work, a micromechanical approach is developed in order to conduct realistic full field finite element simulations of ductile fracture at the microscale. Meshing and remeshing methods relying on the use of Level-Set functions are proposed to discretize the microstructure. Thanks to these methods, the geometric properties of Level-Set functions are preserved, as well as the volume and morphology of each component of the microstructure, even at large plastic strains. These numerical methods are extended to account for cracks and model the failure of some components of the microstructure, or interfaces between them. A new contact detection method based on mesh adaptation is also developed. The interest of these numerical developments and micromechanical models is first demonstrated at the scale of representative volume elements with statistically generated microstructures. Then, a new methodology is proposed to conduct simulations of real microstructures observed via in-situ X-ray laminography, with boundary conditions that are measured using digital volume correlation techniques.
Current situation: Modesar is Postdoctoral Fellow at Northwestern University, Evanston, USA

CSMA also selected two PhD thesis for the ECCOMAS Olympiads 2016:

Tianyi Li and Boris Lossouarn were selected to represent CSMA at the Seventh ECCOMAS PhD Olympiad, organized in the framework of the IV ECCOMAS Young Investigators Conference (YIC 2017).

Tianyi Li : Gradient Damage Modeling of Dynamic Brittle Fracture Variational Principles and Numerical Simulations umerical methods for the yield design of civil engineering structures
Advisors: Jean-Jacques MARIGO, Serguei POTAPOV Ecole Polytechnique and Daniel GUILBAUD CEA Saclay

In civil engineering, mechanical integrity of the reinforced concrete structures under severe transient dynamic loading conditions is of paramount importance for safety and calls for an accurate assessment of structural behaviors in the presence of dynamic crack propagation. In this work, we focus on the constitutive modeling of concrete regarded as an elastic-damage brittle material. The strain localization evolution is governed by a gradient-damage approach where a scalar field achieves a smeared description of dynamic fracture phenomena. The contribution of the present work is both theoretical and numerical. We propose a variationally consistent formulation of dynamic gradient damage models. A formal definition of several energy release rate concepts in the gradient damage model is given and we show that the dynamic crack tip equation of motion is governed by a generalized Griffith criterion. We then give an efficient numerical implementation of the model based on a standard finite-element spatial discretization and the Newmark time-stepping methods in a parallel computing framework. Simulation results of several problems are discussed both from a computational and physical point of view. Different damage constitutive laws and tension-compression asymmetry formulations are compared with respect to their aptitude to approximate brittle fracture. Specific properties of the dynamic gradient damage model are investigated for different phases of the crack evolution: nucleation, initiation, propagation, arrest, kinking and branching. Comparisons with experimental results are also performed in order to validate the model and indicate its further improvement.
Current situation: Tianyi is currently R&D Engineer at Promold in Paris and works on multiphysics modeling of fiber-reinforced thermoplastics



Boris Lossouarn: Multimodal vibration damping of structures coupled to their analogous piezoelectric networks
Supervisors: Jean-François Deü, Mathieu AUCEJO, LMSSC, Cnam (Paris)

Structural vibrations can be reduced by benefiting from the electromechanical coupling that is offered by piezoelectric materials. In terms of passive damping, piezoelectric shunts allow converting the vibration energy into electrical energy. Adding an inductor in the circuit creates an electrical resonance due to the charge exchanges with the piezoelectric capacitance. By tuning the resonance of the shunt to the natural frequency of the mechanical structure, the equivalent of a tuned mass damper is implemented. This strategy is extended to the control of a multimodal structure by increasing the number of piezoelectric patches. These are interconnected through an electrical network offering modal properties that approximate the behavior of the structure to control. This multi-resonant network allows the simultaneous control of multiple mechanical modes. An adequate electrical topology is obtained by discretizing the mechanical structure and applying the direct electromechanical analogy. The analogous network shows inductors and transformers, whose numbers and values are chosen according to the frequency band of interest. After focusing on the design of suitable magnetic components, the passive control strategy is applied to the damping of one-dimensional structures as bars or beams. It is then extended to the control of thin plates by implementing a two-dimensional analogous network.
Current situation:. Boris holds a Postdoctoral research position at Université de Liège, Liège, Belgium (Co-funding ULg-Cnam).

conference diary planner

3 - 5 July 2017 **CMN 2017 - Congreso de Métodos Numéricos en Ingeniería**
Venue: Valencia, España *Contact:* http://congress.cimne.com/CMN2017/

11 - 14 July 2017 **2nd Int. Conference Mechanics of Composites**
Venue: Bologna, Italy *Contact:* https://sites.google.com/a/gcloud.fe.up.pt/mechcomp2016/

17 - 21 July 2017 **USNCCM14 - 14th U.S. National Congress on Computational Mechanics**
Venue: Montreal, Canada *Contact:* http://14.usnccm.org/

21 - 23 Aug. 2017 **MFET 20178 - Modern Finite Element Technologies - Mathematical and Mechanical Aspects**
Venue: Bad Honnef, Germany *Contact:* http://www.eccomas.org/

5 - 7 Sept. 2017 **COMPLAS 2017 - XIV International Conference on Computational Plasticity**
Venue: Barcelona, Spain *Contact:* http://www.eccomas.org/

6 - 8 Sept. 2017 **Advances in Integrated Computational and Experimental Methods for Additive Manufacturing,**
Venue: Golden, CO, USA *Contact:* http://aicem-am2017.usacm.org/

11 - 13 Sept. 2017 **IGA2017 - International Conference on Isogeometric Analysis**
Venue: Pavia, Italy *Contact:* http://congress.cimne.com/iga2017

12 - 14 Sept. 2017 **Computational Modelling of Multi-Uncertainty and Multi-Scale Problems**
Venue: Porto, Portugal *Contact:* https://comus17.com/

13 - 15 Sept. 2017 **YIC2017 - 4th ECCOMAS Young Investigators Conference**
Venue: Politecnico di Milano, Italy *Contact:* https://www.eko.polimi.it/index.php/YIC2017/conf

13 - 16 Sept. 2017 **CMM-2017 - 22nd International Conference on Computer Methods in Mechanics**
Venue: Lublin, Poland *Contact:* http://cmm2017.pollub.pl/

20 - 22 Sept. 2017 **6th ECCOMAS Thematic Conference on the Mechanical Response of Composites**
Venue: Eindhoven, The Netherlands *Contact:* https://www.tue.nl/

20 - 27 Sept. 2017 **MSF 2017 - 3rd Int. Conference on Multiscale Computational Methods for Solids & Fluids**
Venue: Ljubljana, Slovenia *Contact:* http://www.eccomas-msf-2017.eu/

26- 28 Sept. 2017 **PARTICLES 2017 - V International Conference on Particle-based Methods**
Venue: Hannover, Germany *Contact:* http://www.eccomas.org/

2 - 7 Oct. 2017 **Residual and Least Squares Finite Element Methods**
Venue: Portland, USA *Contact:* https://sites.google.com/pdx.edu/dpg/home

9 - 11 Oct. 2017 **Structural Membranes 2017 - 8th Int. Conference on Textile Composites & Inflatable Structures**
Venue: Munich, Germany *Contact:* http://congress.cimne.com/membranes2017

11 - 13 Oct. 2017 **11th SSTA - 11th International Conference "Shell Structures: Theory and Applications"**
Venue: Gdańsk, Poland *Contact:* http://www.ssta.pg.gda.pl

11 - 13 Oct. 2017 **GACM2017 - The 7th GACM Colloquium on Computational Mechanics**
Venue: Stuttgart, Germany *Contact:* https://www.gacm2017.uni-stuttgart.de/

15 - 18 Oct. 2017 **COMPSAFE 2017 - 2nd International Conference on Computational Engineering & Science for Safety & Environmental Problems**
Venue: Chengdu, China *Contact:* http://compsafe2017.org/

18 - 20 Oct. 2017 **VipIMAGE2017- Conference on Computational Vision and Medical Image Processing**
Venue: Porto, Portugal *Contact:* https://paginas.fe.up.pt

7 - 10 Nov. 2017 **ENIEF 2017 - XXIII Congreso sobre Métodos Numéricos y sus Aplicaciones**
Venue: Uni. Nacional de la Plata, Argentina *Contact:* http://congresos.ing.unlp.edu.ar

15 - 16 Jan. 2018 **Nonlocal Methods in Fracture**
Venue: Austin, TX, USA *Contact:* http://nmf2018.usacm.org/

5 - 9 June 2018 **USCTAM 2018 - 18th U.S. National Congress of Theoretical & Applied Mechanics Co-Organized with the Chinese Society of Theoretical & Applied Mechanics**
Venue: Chicago, Illinois, USA *Contact:* http://sites.northwestern.edu/usnctam2018/

11 - 15 June 2018 **ECCM - ECFD Conference 2018 - 7th European Conference on Computational Fluid Dynamics & 6th European Conference on Computational Mechanics**
Venue: Glasgow, UK *Contact:* www.eccm-ecfd2018.org

22 - 27 July 2018 **WCCM-XIII - PANACM-II : 13th World Congress on Computational Mechanics jointly organized with the 2nd Pan American Congress on Computational Mechanics**
Venue: New York, USA *Contact:* http://www.wccm2018.org/

18 - 21 Dec. 2019 **APCOM 2019 - 7th Asian Pacific Congress on Computational Mechanics**
Venue: Taipei, Taiwan *Contact:* http://www.apcom2019.org/