SIMULATION OF PLANE STRAIN FIBER COMPOSITE PLATES IN BENDING THROUGH A BEM/ACA/HM FORMULATION

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Abstract. *In the present work large scale, plane strain elastic problems dealing with the bending of unidirectional fiber composite plates are solved by means of a Boundary Element method (BEM) accelerated via Adaptive Cross Approximation (ACA) and Hierarchical Matrices (HM) techniques. The composite plate is modeled as a large number of periodically or randomly distributed cylindrical elastic fibers embedded in a matrix medium. Each of the considered problems is treated through boundary discetizations with almost one million Degrees of Freedom (DoFs). The work aims to study microstructural effects due to the size of the fibers and the validity of the homogenization generalized self-consistent method proposed by Christensen (J. Mech. Phys. Solids, Vol. 38, pp. 379-404, 1990).*

1 INTRODUCTION

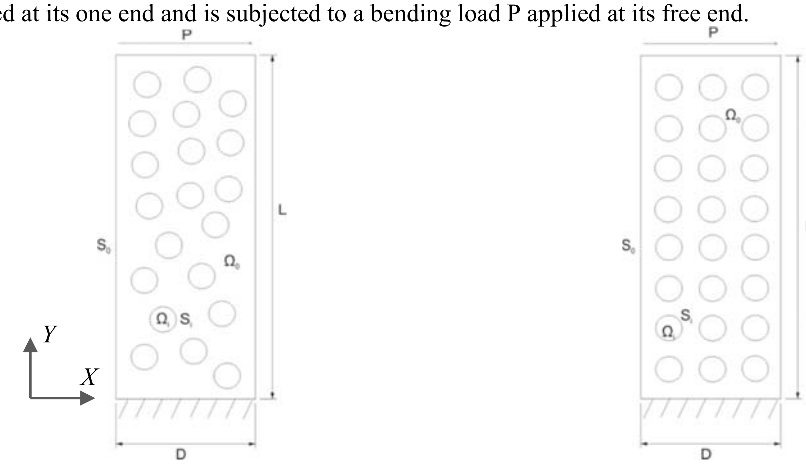
Composite materials are used in advanced mechanical structures with remarkable gain in strength and weight. However, due to their microstructural complexity, their computational modeling is still confined to small specimens corresponding to small numbers of inclusions. To overcome this difficulty, a plethora of theoretical and numerical homogenization techniques have been proposed so far in the literature predicting the effective properties of the composite. Most of them are based on the analysis of a unit cell consisting of an inclusion embedded in a matrix medium and obeying to specified boundary conditions. A widely used and very representative homogenization technique is the Generalized Self-Consistent Method (GSCM) proposed by Christensen [1] for fiber and particulate composite materials. The main goal of the present work is to find out the smallest size of a fiber composite the effective properties of which can be effectively predicted by the GSCM. To this end, the fiber composite material is simulated as a plate with a large number of periodically or randomly distributed unidirectional reinforcements subjected to a bending loading across the direction of the fibers.

The above described problem is numerically solved by means of a Boundary Element Method (BEM) accelerated via Adaptive Cross Approximation (ACA) and Hierarchical Matrices (HM) techniques (Bebendorf [2]). Conventional BEM formulations produces full populated and non-symmetric collocation matrices [A] increasing thus the computational cost and confining the method to the solution of relatively small problems. More precisely, the computation of all elements of [A] requires $O(N^2)$ algebraic operations, with N being the number of unknowns. Furthermore, the solution of the system of equations requires $O(N^3)$ operations if a direct solver is utilized and $O(K\times N^2)$ operations if an iterative solver is used, with K being the number of iterations. A solution to that problem is the use of a BEM enhanced by HM and ACA techniques that accelerate drastically the computation of matrix [A] and also reduce the memory requirements. That acceleration is possible due to the nature of the fundamental solutions, which are functions of the distance between the source and field points and thus only a small number of elements of the collocation matrix [A] are calculated, while the rest of them are approximated via the already evaluated elements~~.~~ According to ACA/BEM, the matrix [A] is organized into a hierarchical structure of blocks depended on the geometry of the problem. Applying a geometrical criterion the blocks are characterized either as non-admissible, where the ACA algorithm is inefficient and thus the conventional BEM is employed or admissible where ACA is effective and is used to calculate only a small number of their rows and columns. Each admissible block is represented in a low rank matrix format via the product of two matrices formed by the previously calculated rows and columns, respectively. This low rank format in conjunction with an iterative solver leads to significant reductions in memory requirements and CPU time due to the acceleration of the matrix vector multiplication. More details one can find in the works of Bebendorf and Grzhibovskis [3], Benedetti et al. [4], Benedetti et al. [5] and Zechner [6] for elastostatic problems and Benedetti and Alliabadi [7], Messner and Schanz [8] and Millazzo et al. [9] for elastodynamic ones.

2 PROBLEM DESCRIPTION AND SOLUTION METHOD

2.1 Problem description and conventional Boundary Element Method formulation

Consider a 2*D* rectangular fiber composite plate of length *L* and width *D*, ~~as~~ shown in figs. 1(a) and (b). The plate occupies a region Ω_0 of boundary S_0, ~~is~~ made of a matrix material with Young's modulus E_M and Poisson's ratio v_M and ~~is~~ reinforced ~~with~~ by N_f identical circular fibers of radius α with Young's modulus and Poisson's ratio E_F and v_F, respectively. The fibers are either randomly distributed (fig. 1(a)) or periodically arranged in a square pattern (fig. 1(b)), while their volume fraction is u_f. Each fiber occupies a region Ω_i of boundary S_i, where i= 1, N_f. The plate is fixed at its one end and is subjected to a bending load P applied at its free end.



(a) (b)

Figure 1. 2D rectangular plate with (a) randomly distributed and (b) periodically arranged fibers

The~~-~~solution of the above described 2D elastostatic problem can be obtained by solving a combined system of boundary integral equations written for the matrix and each of the N_f fibers. The boundary integral equations for the matrix and for the i^{th} fiber are written as:

$$\tilde{\mathbf{c}}(\mathbf{x})\cdot\mathbf{u}(\mathbf{x})+\int_S \tilde{\mathbf{t}}^*(\mathbf{x},\mathbf{y})\cdot\mathbf{u}(\mathbf{y})\,dS_{\mathrm{y}}=\int_S \tilde{\mathbf{u}}^*(\mathbf{x},\mathbf{y})\cdot\mathbf{t}(\mathbf{y})\,dS_{\mathrm{y}} \tag{1}$$

$$\tilde{\mathbf{c}}(\mathbf{x})\cdot\mathbf{u}(\mathbf{x})+\int_{S_i} \tilde{\mathbf{t}}^*(\mathbf{x},\mathbf{y})\cdot\mathbf{u}(\mathbf{y})\,dS_{\mathrm{y}}=\int_{S_i} \tilde{\mathbf{u}}^*(\mathbf{x},\mathbf{y})\cdot\mathbf{t}(\mathbf{y})\,dS_{\mathrm{y}} \tag{2}$$

where $S = S_0 + \sum_{i=1}^{N_f} S_i$, **x** and **y** are points on the boundary, **u** and **t** are the displacement and traction vectors, $\tilde{\mathbf{c}}$ is a free term tensor depended on local geometry at point **x** (for a smooth boundary $\tilde{\mathbf{c}}=1/2\,\tilde{\mathbf{I}}$, with $\tilde{\mathbf{I}}$ being the unity tensor) and $\tilde{\mathbf{u}}^*(\mathbf{x},\mathbf{y})$ and $\tilde{\mathbf{t}}^*(\mathbf{x},\mathbf{y})$ are the 2D free space elastostatic fundamental solutions, written as [10].

$$u_{kj}^*(\mathbf{x},\mathbf{y})=\frac{(1+v)}{4\pi E(1-v)}\left((3-4v)\delta_{kj}\ln\left(\frac{1}{r}\right)+r_{,k}\,r_{,j}\right),\ \text{with}\ k,j=\ 1,\ 2 \tag{3}$$

$$t_{kj}^*(\mathbf{x},\mathbf{y})=\frac{1}{4\pi(1-v)r}\left[\left((1-2v)\delta_{kj}+2r_{,k}\,r_{,j}\right)\frac{\partial r}{\partial n}+(1-2v)\left(r_{,k}\,n_j-r_{,j}\,n_k\right)\right] \tag{4}$$

where r is the distance between the points $\mathbf{x}$ and $\mathbf{y}$, n_j the unit normal vector of the boundary at point $\mathbf{y}$, $r_{,j}$ denotes spatial derivatives of r and $\partial r / \partial n$ is the directional derivative with respect to the normal vector at $\mathbf{y}$.

According to a conventional BEM formulation, the boundary S is discretized into three-noded quadratic or two-noded linear isoparametric line boundary elements with a total number of L nodes. Collocating eqn (1) at all nodes L one obtains the following linear system of algebraic equations of the form

$$\begin{bmatrix} {}^M\tilde{\mathbf{H}}_0^0 & {}^M\tilde{\mathbf{H}}_1^0 & \cdots & {}^M\tilde{\mathbf{H}}_{N_f}^0 \\ {}^M\tilde{\mathbf{H}}_0^1 & {}^M\tilde{\mathbf{H}}_1^1 & \cdots & {}^M\tilde{\mathbf{H}}_{N_f}^1 \\ \vdots & \vdots & \vdots & \vdots \\ {}^M\tilde{\mathbf{H}}_0^{N_f} & {}^M\tilde{\mathbf{H}}_1^{N_f} & \cdots & {}^M\tilde{\mathbf{H}}_{N_f}^{N_f} \end{bmatrix} \cdot \begin{Bmatrix} \mathbf{u}^0 \\ \mathbf{u}^1 \\ \vdots \\ \mathbf{u}^{N_f} \end{Bmatrix} = \begin{bmatrix} {}^M\tilde{\mathbf{G}}_0^0 & {}^M\tilde{\mathbf{G}}_1^0 & \cdots & {}^M\tilde{\mathbf{G}}_{N_f}^0 \\ {}^M\tilde{\mathbf{G}}_0^1 & {}^M\tilde{\mathbf{G}}_1^1 & \cdots & {}^M\tilde{\mathbf{G}}_{N_f}^1 \\ \vdots & \vdots & \vdots & \vdots \\ {}^M\tilde{\mathbf{G}}_0^{N_f} & {}^M\tilde{\mathbf{G}}_1^{N_f} & \cdots & {}^M\tilde{\mathbf{G}}_{N_f}^{N_f} \end{bmatrix} \cdot \begin{Bmatrix} \mathbf{t}^0 \\ \mathbf{t}^1 \\ \vdots \\ \mathbf{t}^{N_f} \end{Bmatrix} \tag{5}$$

where ${}^M\tilde{\mathbf{G}}_\gamma^m$ and ${}^M\tilde{\mathbf{H}}_\gamma^m$ are matrices, formed by integrals containing the kernels (3) and (4), respectively, with the term 1/2 added at the diagonal elements of ${}^M\tilde{\mathbf{H}}_m^m$. The indices m and γ take values 0, 1, 2,…N_f, which correspond to the total number of nodes $L_0, L_1, ,.., L_{Nf}$ ($L = L_0 + \sum_{i=1}^{N_f} L_i$) that the boundaries S_0, $S_{1,\ ...,}$ S_{Nf} have been descritized into, respectively. The vectors $\mathbf{u}^m$ and $\mathbf{t}^m$ contain the nodal displacement and traction vectors of the nodes L_m, respectively.

Similarly, collocating the eqn (2), for all the nodes L_i of the i^{th} fiber and applying the continuity conditions (equal displacements and opposite tractions) at the interface between the matrix and the i^{th} fiber, the following system of algebraic equations can be obtained

$$\left[{}^F\tilde{\mathbf{H}}_i^i\right] \cdot \left\{\mathbf{u}^i\right\} = -\left[{}^F\tilde{\mathbf{G}}_i^i\right] \cdot \left\{\mathbf{t}^i\right\} \tag{6}$$

In systems of equations (5) and (6), all the nodal values of $\mathbf{u}^i$ and $\mathbf{t}^i$ with i=1, 2, ..,N_f are unknown, while the half nodal values of $\mathbf{u}^0$ and $\mathbf{t}^0$ are known by the boundary conditions on the boundary S_0 and the other half are unknown.

When point $\mathbf{x}$ does not coincide with $\mathbf{y}$, the integrals in eqs (1) and (2) are non-singular and can be easily computed numerically by Gauss quadrature. In case where $\mathbf{x}$ coincides with $\mathbf{y}$, the integrals in (1) and (2) become singular, with the integrals containing the kernel (3) being weakly singular of order $\mathrm{O}(\ln r)$ and the integrals containing the kernel (4) being strongly singular of order $\mathrm{O}(1/r)$. The singular integrals are evaluated with high accuracy by applying a direct integration method proposed by Guiggiani [11]. This direct evaluation makes use of a limiting process in the singular part of the kernels and then a semi-analytical integration is performed on a local co-ordinate system of the element, which has the origin at the singular point.

Combing eqs (5) and (6) and rearranging with respect to the boundary conditions valid at boundary S_0, one obtains a system of linear algebraic equations of the form

$$\tilde{\mathbf{A}} \cdot \mathbf{X} = \mathbf{B} \tag{7}$$

where the vectors $\mathbf{X}$ and $\mathbf{B}$ contain all the unknown and known nodal components of the boundary fields, respectively.

In the present work, the solution of the system (7) is obtained using the iterative solver GMRES. Actually, the matrix $\tilde{\mathbf{A}}$ is never formed explicitly, saving significant amount of memory which corresponds to the zero values appearing in $\tilde{\mathbf{A}}$ due to the fact that each fiber has a common interface only with the matrix medium and is not associated with the rest of the fibers. The GMRES multiplications are performed straightforward by considering eqs. (5) and (6). A block left diagonal preconditioner is used to accelerate the convergence of the solution. The dimensions of each block of the preconditioner are chosen to be equal to the number of degrees of freedom of a fiber, for a particular discretization. Each block is inverted by using the LU decomposition algorithm.

2.2 Hierarchical ACA accelerated BEM

In conventional BEM, the matrix $\tilde{\mathbf{A}}$ is generally a full populated matrix and thus, the memory demand is of $\mathrm{O}(N^2)$ which is prohibitive for solving realistic problems, where the degrees of freedom (DOFs) N are of the order of hundreds of thousands. In the present work, in order to overcome the conventional BEM memory limitations and solve the above described problem for a large number of fibers, a hierarchical ACA accelerated BEM is used. Furthermore, a significant reduction of the solution time is also accomplished.

According to the proposed method, the matrices $\tilde{\mathbf{H}}$ and $\tilde{\mathbf{G}}$, appearing in eqs (5) and (6), are represented hierarchically using a block tree structure. Under simple geometric considerations the blocks, which correspond to large distances r in kernels (3) and (4), are characterized as far field blocks (or admissible) and they are compressed by means of low rank matrices found by ACA, with respect to a prescribed accuracy ε. The rest blocks of the tree, which are dominated by the singular behavior of the kernels (3) and (4), are characterized as near field blocks (or non-admissible) and are calculated as in conventional BEM.

Let's consider an admissible block sub-matrix $\tilde{\mathbf{M}}$ of matrices $\tilde{\mathbf{H}}$ or $\tilde{\mathbf{G}}$, with dimensions $N \times L$ and a full rank $R = \min\{N, L\}$. The block $\tilde{\mathbf{M}}$ can be represented as:

$$\tilde{\mathbf{M}} = \tilde{\mathbf{M}}^{(K)} + \tilde{\mathbf{R}}^{(K)} \tag{8}$$

where $\tilde{\mathbf{M}}^{(K)}$ is a K-rank approximation of $\tilde{\mathbf{M}}$, with k being less equal than R and $\mathbf{R}^{(K)}$ is the residual of the approximation. $\tilde{\mathbf{M}}^{(K)}$ can be written as:

$$\tilde{\mathbf{M}}^{(K)} = \sum_{i=1}^{K} \mathbf{a}^i (\mathbf{b}^i)^T = \tilde{\mathbf{A}} \cdot \tilde{\mathbf{B}}^T \tag{9}$$

where $\mathbf{a}^i$ and $\mathbf{b}^i$ are vectors, of dimensions N and L, respectively, found such that the following relation holds:

$$\left\|\mathbf{R}^{(K)}\right\|_F \leq \varepsilon \left\|\tilde{\mathbf{M}}\right\|_F \tag{10}$$

where $\|\cdot\|_F$ denotes the Frobenius norm [2]. Matrices $\tilde{\mathbf{A}}$ and $\tilde{\mathbf{B}}$, of dimensions $N \times K$ and $L \times K$, respectively are formed by the vectors $\mathbf{a}^i$ and $\mathbf{b}^i$ as follows:

$$\begin{aligned} \tilde{\mathbf{A}}_{N\times K} &= \left\{\mathbf{a}^1 \quad \mathbf{a}^2 \quad \ldots \quad \mathbf{a}^3\right\} \\ \tilde{\mathbf{B}}_{L\times K} &= \left\{\mathbf{b}^1 \quad \mathbf{b}^2 \quad \ldots \quad \mathbf{b}^3\right\} \end{aligned} \tag{11}$$

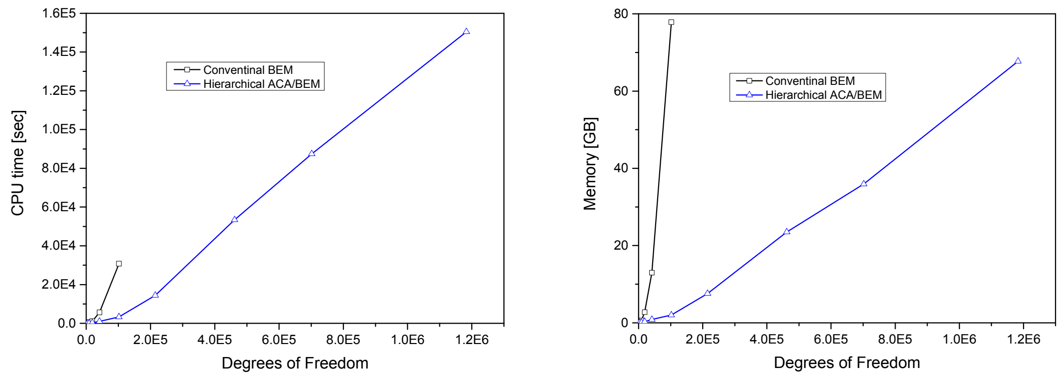
The memory requirements and matrix multiplication CPU cost of a low rank block are $O\left(K\left(N+L\right)\right)$, while for the corresponding full rank representation are $O(N \times L)$. It is obvious that the low rank approximation is efficient when the condition $K(N+L) << N \cdot L$ is true. The best low rank approximation for a given accuracy ε, can be found by means of the Singular Value Decomposition(SVD) [2].

Although the best low rank approximation (the minimal rank K) can be achieved via SVD, its cubic CPU cost with respect to the rank of the matrix. is prohibitive for real world applications. Thus, instead of the SVD, the Adaptive Cross Approximation (ACA is used. The main idea of ACA is to construct a representation of $\tilde{\mathbf{M}}^{(K)}$ (eqn 9) by suitably choosing a small subset of the rows and columns of a matrix $\tilde{\mathbf{M}}$. Based on this idea two algorithms have been developed; ACA with full pivoting which is an $O(K^2 \cdot N \cdot L)$ algorithm and requires as starting point the calculation of the entire matrix $\tilde{\mathbf{M}}$, and the partially pivoted ACA, which is an $O\left(K^2\left(N+L\right)\right)$ algorithm requiring the calculation of only a small part of $\tilde{\mathbf{M}}$. The partially pivoted ACA is faster and consumes less memory than the fully pivoted one, but the approximation accuracy ε is not guaranteed because its stopping criterion is heuristic since the $\left\|\tilde{\mathbf{M}}\right\|_F$ in eqn (10) cannot be calculated exactly. In the present work the above mentioned drawback is cancelled applying extra convergence checks. We have seen that for small admissible blocks, where the rank K is comparable with the full rank R, the fully pivoted ACA is more efficient than the partially pivoted one. On the contrary, for large admissible blocks, where K is usually orders of magnitude smaller than R, the partially pivoted ACA is much more efficient. In the present work, full pivoted ACA is used for admissible blocks with full rank R<100.

2.3 Comparison between conventional and Hierarchical ACA/BEM

In order to demonstrate the efficiency of the proposed hierarchical ACA accelerated BEM formulation, the 2D elastostatic bending problem, described in section 2.1, is solved using both ACA and conventional BEM.

In figs 2(a) and (b) the normalized total CPU time and memory requirements as function of DOFs N are depicted, respectively. As total CPU time is considered the time required for the evaluation of the matrices $\tilde{\mathbf{H}}$ and $\tilde{\mathbf{G}}$ as well as the time spent for the system solution. The total CPU time is normalized by the corresponding time required for the solution of the problem for 100000 DOFs by means of the conventional BEM. Observing figs 2(a) and (b), one can say that the O(N^2) memory demand in conventional, is verified.



(a) (b)

Figure4. Total CPU time (a) and the memory demand (b), using conventional BEM and Hierarchical ACA/BEM

The CPU time and memory requirements for solving a 2D elastic problem with 10^5 DOFs through conventional BEM are about the same with the corresponding ones needed for the same problem with 10^6 DOFs and solved with the aid of partially pivoted ACA.

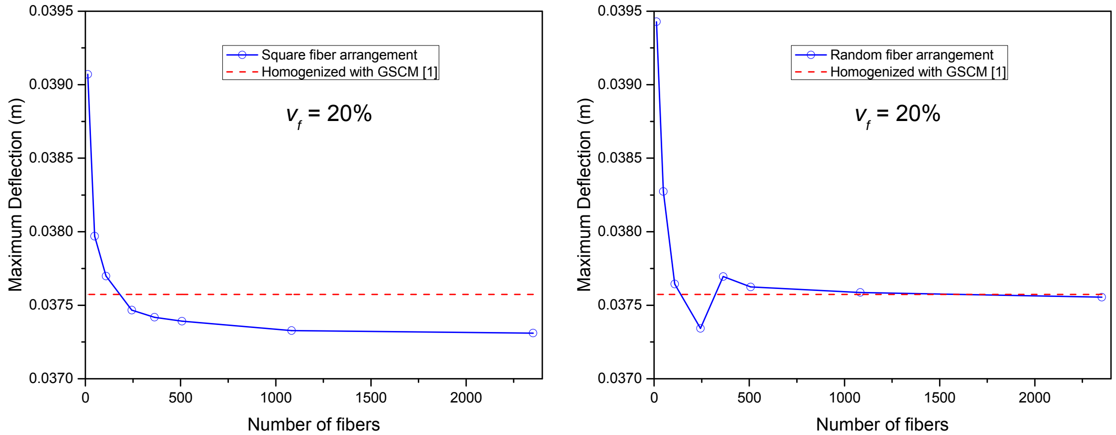
3 NUMERICAL RESULTS

In the present work, the bending problem of the composite plate, described in section 2.1, is solved, by means of the partially pivoted ACA-BEM, for various numbers of fibers and volume fractions u_f, in order to investigate the microstructural effects of the fibers' size with respect to the dimensions of the plate. The results are compared to those obtained by solving the same bending problem, considering the plate homogeneous with effective material properties provided by the GSCM [1]. The problem parameters are listed in the table 1.

Geometry of the plate		**Material properties**			**Bending Load**	
		Property	**Matrix**	**Fiber**		
Length L (m)	9	Young's modulus E (GPa)	66	360	P (MPa)	10
Width D (m)	3	Poisson's ratio v	0.31	0.25		

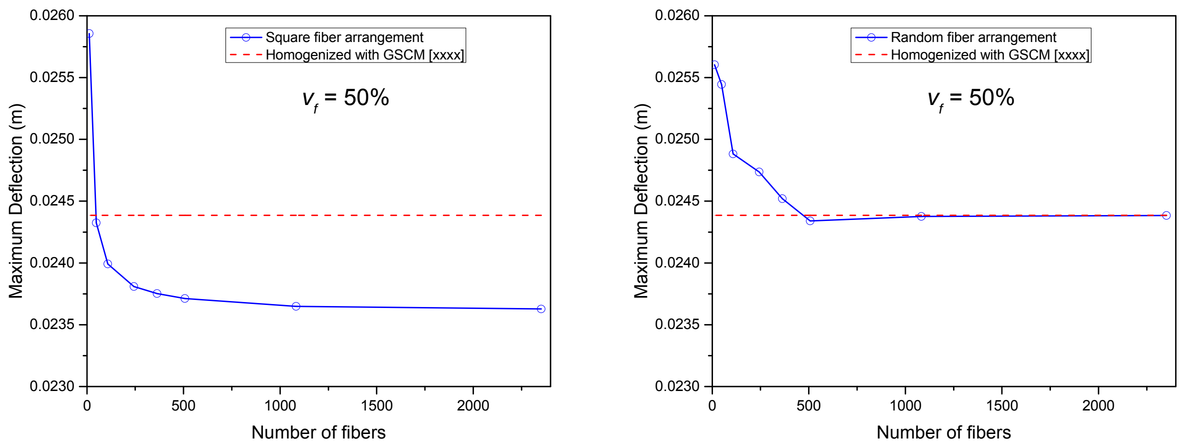
Table 1. Problem parameters

In Figures 3(a,b) and 4(a,b), the maximum deflection of the composite plate with periodically and randomly distributed fibers is depicted for volume fractions 0.20 and 0.50, respectively. Keeping the volume fraction constant, all the problems are solved for different number of fibers, as it is shown in x-axis of both figures.



(a) (b)

Figure 3. Maximum deflection of the composite plate as a function of fibers' radius a, with fibers (a) periodically arranged in a square pattern and (b) randomly distributed, for a volume fraction u_f= 0.20

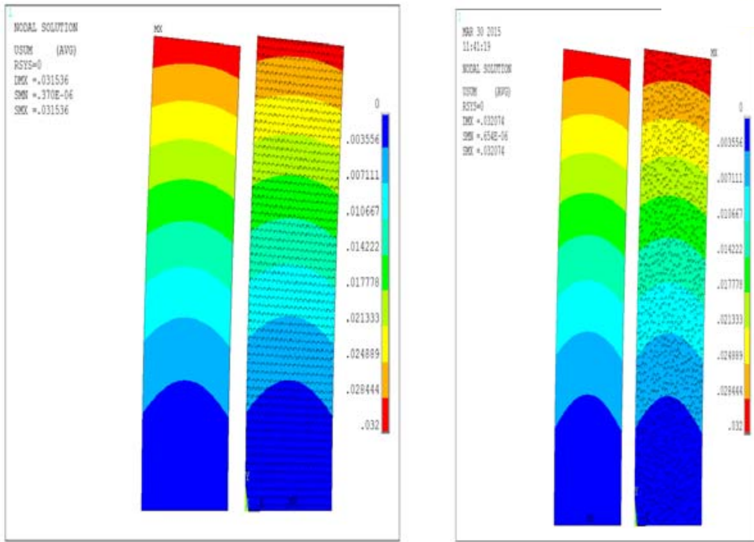


(a) (b)

Figure 4. Maximum deflection of the composite plate as a function of fibers' radius a, with fibers (a) periodically arranged in a square pattern and (b) randomly distributed, for a volume fraction u_f= 0.50

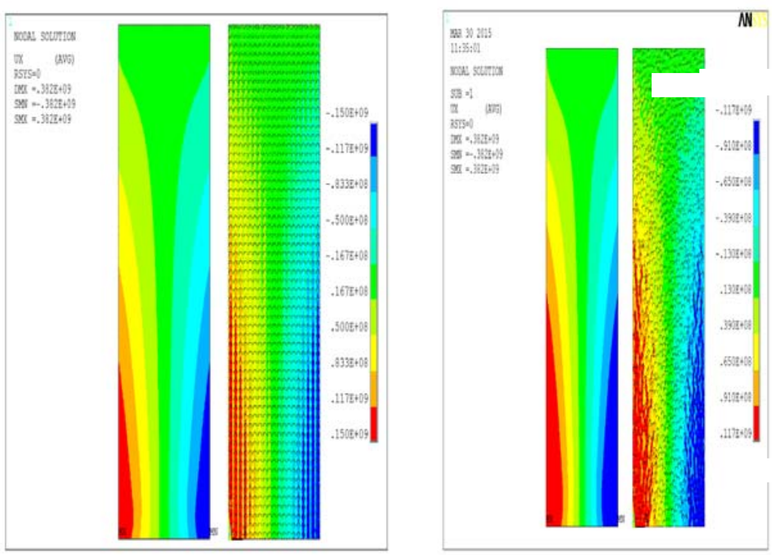
Figures 3 and 4 reveal the following very interesting conclusions: (i) there are significant microstructural effects for a number of fibers less than 500, (ii) as the fibers' size decreases their microstructural effects become less significant, (iii) for a number of fibers greater than 1000 the microstructural effects become negligible, (iv) the GSCM provides accurate predictions only for randomly distributed fibers and for large number of fibers,.(v) the plate with periodically arranged fibers is stiffer than the one-with randomly distributed fibers.

Figure 5 and 6 depict the contours of displacement u_x and normal stress σ_y, respectively for the plates with periodically arranged and randomly distributed fibers with N_f=1083 and u_f=0.35, as well as for the corresponding homogenized plate.



(a) (b) (c)

Figure 5. Contours of the displacement magnitude, for N_f=1083 and u_f =0.35; (a) homogenized plate (b) periodically arranged fibers and (c) randomly distributed fibers.



(a) (b) (c)

Figure 6. Contours of normal bending stress, for N_f=1083 and u_f =0.35; (a) homogenized plate (b) periodically arranged fibers and (c) randomly distributed fibers.

4 CONCLUSIONS

In the present work a large scale elasticity problem concerning the simulation of a fibrous composite plate with a large number of fibers was solved by means of a proposed ACA/BEM. For the simulation, models with up to one million DOFs were used. The proposed methodology reduces the solution time and the memory requirements significantly compared with the corresponding ones needed by the conventional BEM.

The obtained numerical results reveal that there are significant microstructural effects due to the size of the fibers. Also, significant differences were observed in the numerical results between the two examined arrangements of the fibers, i.e., randomly distributed and periodically arranged in a square pattern. The examined micromechanical model GSCM provides accurate predictions for the effective material properties of the composite only for randomly distributed fibers under the constraint that the number of fibers must be large enough in order to the microstructural effects become negligible.

ACKNOWLEDGEMENT

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REFERENCES

[1] Christensen, R.M. (1990), "A critical evaluation for a class of micro mechanics models", *J Mech Phys Solids*, Vol. 38, pp. 379-404.

[2] Bebendorf, M. (2000), "Approximation of boundary element matrices", *Numerische Mathematik*, Vol. 86, pp. 565-589.

[3] Bebendorf, M., Grzhibovskis, R., (2006), "Accelerating Galerkin Bem for linear elasticity using adaptive cross approximation", *Mathematical Methods in the Applied Sciences*, Vol. 29, pp. 1721-1747.

[4] Benedetti, I., Alliabadi, M.H., Davi, G., (2008),"A fast 3D dual boundary element method based on hierarchical matrices", *International Journal of Solids and Structures*, Vol. 45, pp. 2355-2376.

[5] Benedetti, I., Milazzo A., Alliabadi, M.H, (2009), "A fast dual boundary element method for 3d anisotropic crack problems", *Int J Numer Methods Eng*, Vol. 80(10), pp. 1356-1378.

[6] Zechner, J. (2012), *A Fast Boundary Element Method with Hierarchical Matrices for Elastostatics and Plasticity*., PhD thesis, 2012, http://www.ifb.tugraz.at/juergen/phd_zechner_2012.pdf.

[7] Benedetti, I., Alliabadi, M.H, (2009), "A fast hierarchical dual boundary element method for three dimensional elastodynamic crack problems", *Int J Numer Methods Eng,* Vol 84(9), pp. 1356-1378.

[8] Messner, M., Schanz, M., (2010), "An accelerated symmetric time-domain boundary element formulation for elasticity", *Engineering Analysis with Boundary Elements*, Vol. 34, pp. 944-955.

[9] Millazzo, A., Benedetti, I., Alliabadi, M.H, "Hierarchical fast BEM for anisotropic time-harmonic 3-D elastodynamics", *Computers and Structures*, Vol. 96-97, pp. 9-24.

[10] Polyzos, D., Tsinopoulos, S.V. and Beskos, D.E. (1998), "Static and dynamic boundary element analysis in incompressible linear elasticity", *European Journal of Mechanics – A/Solids*, Vol. 17, pp. 515-536.

[11] Guiggiani, M. and. Gigante, A. (1990), "A general algorithm for multidimensional Cauchy principal value integrals in the boundary element method", *J. Appl. Mech. ASME, Vol.* 57, pp. 906-915.

CONGRESS PROGRAM

Sunday, July 12th 2015
Papastratos Complex - Tholos

18:00-20:00 **Reception - Registration Desk Open**

Monday, July 13th 2015
Papastratos Complex - Tholos

8:00-9:00 **Registration Desk Open**

Monday, July 13th **8:45-10:00**
Papastratos Complex, Room 1

8:45 Congress Opening: *Nikos A. Pelekasis and Georgios E. Stavroulakis*
Welcome addresses: Prof. *Zisis Mamouris,*
Vice Rector of Research, University of Thessaly

Manolis Papadrakakis,
President of GRACM

9:00 Plenary Lecture #1
Chair: C. Papadimitriou

P. Koumoutsakos
Τα παντα ρει: Simulations and Uncertainties

Monday, July 13th **10:00 - 11:40**
Parallel Session D1-A1, Room 1

Mechanics of Materials I
Chair: N. Aravas, A. Giannakopoulos

10:00 **ON THE THERMOELASTIC RESPONSE OF A GRADIENT ELASTIC HALF-SPACE SUBJECTED TO THERMAL SHOCK ON THE BOUNDARY**
Th. Papathanasiou, P. Gourgiotis, F. Dalcorso and Th. Zisis

10:20 **FINITE ELEMENT MODELING OF THE COMPOSITE REINFORCED BY GRAINS**
A. Shimanovsky, V. Yakubovich and Y. Pleskachevskii

10:40 **MULTISCALE HOMOGENIZATION OF MULTILAYERED STRUCTURES**
D. Tsalis, K. Bonnay, G. Chatzigeorgiou and N. Charalambakis

11:00 **A MICRO-SCALE STRUCTURAL RESPONSE COMPARISON BETWEEN GFRP AND CFRP WIND TURBINE BLADES**
E. Theotokoglou and G. Balokas

11:20 **A FINITE ELEMENT METHOD FOR THE SIMULATION OF CRYSTAL DEFECTS**
K. Baxevanakis and A. Giannakopoulos

Monday, July 13th **10: 00 - 11: 40**
Parallel Session D1-A2, Room 2

Theoretical Fluid Mechanics
Chair: D. Papageorgiou, V. Bontozoglou

10:00 **STICK-SLIP MOTION AND HYSTERESIS BEHAVIOUR OF DROPLETS WITH DYNAMIC VOLUME VARIATION**
M. Pradas, N. Savva, J. Benziger, I. Kevrekidis and S. Kalliadasis

10:20 **THE ASYMPTOTIC DESCRIPTION OF THE MOVING CONTACT LINE AS A TEXTBOOK SINGULAR PERTURBATION PROBLEM: CRACKING AN OLD NUT**
D. Sibley, A. Nold and S. Kalliadasis

10:40 **RADIATION AND PRESSURE GRADIENT EFFECTS ON THE INCOMPRESSIBLE LAMINAR BOUNDARY LAYER FLOW**
A. Siokis and M. Xenos

11:00 **PROPAGATION OF ACOUSTIC-GRAVITY WAVES IN INHOMOGENEOUS OCEAN ENVIRONMENT GENERATED BY SEA BOTTOM DEFORMATION**
A. Karperaki, K. Belibassakis and Th. Papathanasiou

11:20 **DOWNSTREAM DISTURBANCE DECAY IN STEADY AND PULSATILE CHANNEL FLOWS: IMPLICATIONS FOR THE DEVELOPMENT OF A SIMPLIFIED DOMAIN DECOMPOSITION MODEL**
S. Yiantsios

Monday, July 13th **10: 00 - 11: 40**
Parallel Session D1-A3, Room 3

Finite/Boundary Elements I
Chair: G. Tsamasphyros, M. Papadrakakis

10:00 **CONTINUAL AND FINITE ELEMENT MODELLING OF ELECTRICALLY ACTIVE MATERIALS WITH MICROSTRUCTURE AND SURFACE EFFECTS**
A. Nasedkin

10:20 **MECHANICAL MODELING OF HELICAL ASSEMBLIES IN TWO DIMENSIONS, COMPUTATIONAL MERITS AND APLICATIONS**
N. Karathanasopoulos

10:40 **HIGH ORDER FINITE ELEMENTS FOR FOURTH ORDER PROBLEMS USING C^1 BASIS FUNCTIONS**
Ch. Xenophontos

11:00 **A MODIFIED DECOUPLED SCALED BOUNDARY-FINITE ELEMENT METHOD FOR MODELING 2D IN-PLANE-MOTION TRANSIENT ELASTODYNAMIC PROBLEMS IN SEMI-INFINITE MEDIA**
D.-P. Kontoni and M. I. Khodakarami

11:20 **AN A POSTERIORI ERROR ANALYSIS FOR INTERIOR PENALTY DISCONTINUOUS GALERKIN FINITE ELEMENT METHOD OF A TWO-DIMENSIONAL PROBLEM OF STRAIN GRADIENT ELASTICITY**
K. Eptaimeros and G. Tsamasphyros

11:40 **Coffee Break**

Monday, July 13th **12:00 - 13:40**
Parallel Session D1-B1, Room 1

Mechanics of Materials II
Chair: E. Theotokoglou, V. Dimitriou

12:00 **DISCRETE MODELING OF CEMENTITIOUS MATERIALS: FAILURE SURFACES IN PLANE STRESS/STRAIN**
V. Balopoulos, N. Archontas and S. Pantazopoulou

12:20 **FINITE ELEMENT STUDY OF THE INITIAL STAGES OF EXPLOSION OF SINGLE WIRE Z-PINCH VALIDATED BY EXPERIMENTS**
E. Kaselouris, A. Skoulakis, V. Dimitriou, I. Fitilis, I. Nikolos, E. Bakarezos, N. Papadogiannis and M. Tatarakis

12:40 **FORMATION OF ADIABATIC SHEAR BANDS IN ORTHOGONAL MACHINING OF TI6AL4V ALLOY**
O. Friderikos, A. Korlos, C. David, D. Sargis and G. Mansour

13:00 **LIMIT LOAD AND DEFORMATION ANALYSIS OF STEEL FRAMES WITH NONLINEAR CONSTITUTIVE BEHAVIOR AND MULTI-COMPONENT INTERACTION**
M.-M. Manola and V. Koumousis

13:20 **TRANSIENT STRESSES OF A FUNCTIONALLY GRADED PROFILE WITH TEMPERATURE-DEPENDENT MATERIALS UNDER THERMAL SHOCK**
A. Nikolarakis and E. Theotokoglou

Monday, July 13th **12:00 - 13:40**
Parallel Session D1-B2, Room 2

Mini-symposium 1-I (Drops)
Organizers: D. Papageorgiou, V. Bontozoglou and N. Pelekasis
Chair: M. Blyth, A. Oron

12:00 **CLOUD ON THE HORIZON: HIGH SPEED DROPLET IMPACT, SPREADING AND THIN FILM DYNAMICS**
R. Cimpeanu, D. Papageorgiou, M. Kravtsova and A. Ruban

12:20 **EQUILIBRIUM FLUID STRUCTURES IN PROTOTYPICAL NANOSYSTEMS**
P. Yatsyshin, N. Savva and S. Kalliadasis

12:40 **EFFICIENT MODELING OF DROPLET SPREADING ON ROUGH SURFACES**
N. Chamakos, G. Karapetsas, M. Kavousanakis and A. Papathanasiou

13:00 **COMPUTATION OF WETTING STATES ON PATTERNED SURFACES WITH A MODIFIED PHASE-FIELD METHOD**
G. Pashos, G. Kokkoris and A. Boudouvis

13:20 **FLOW ARRANGEMENT AND HEAT TRANSFER CAPABILITIES OF A PLASMA FACING COMPONENT IN THE FORM OF A CPS**
L. Benos and N. Pelekasis

Monday, July 13th **12:00 - 13:40**
Parallel Session D1-B3, Room 3

Finite/Boundary Element Methods II
Chair: S. Karamanos, V. Koumousis

10:00 **SIMULATION OF LONG-RANGE ULTRASONIC GUIDED WAVE PROPAGATION IN PIPES WITH DEFECTS USING FINITE ELEMENT METHOD**
A. Nasedkina, A. Alexiev and J. Malachowski

10:20 **A WEAK FORMULATION FOR MECHANICAL SYSTEMS WITH SCLERONOMIC MOTION CONSTRAINTS**
N. Potosakis, E. Paraskevopoulos and S. Natsiavas

10:40 **SIMULATION OF PLANE STRAIN FIBER COMPOSITE PLATES IN BENDING THROUGH A BEM/ACA/HM FORMULATION**
Th. Gortsas, St. Tsinopoulos and D. Polyzos

11:00 **A HYSTERETIC FORMULATION FOR ISOGEOMETRIC ANALYSIS AND SHAPE OPTIMIZATION OF PLANE STRESS STRUCTURES**
A. Moysidis and V. Koumousis

11:20 **STATIC ANALYSIS OF THICK LAYERED ANISOTROPIC PLATES WITH BEM**
N. Babouskos and J. Katsikadelis

13:40 **Lunch Break**

Monday, July 13th **15: 00 - 16: 40**
Parallel Session D1-C1, Room 1

Structural Mechanics I
Chair: E. Sapountzakis, O. Panagouli

15:00 **COMPUTER MODELING OF THE DEVICE FOR FASTENING PIPES ON RAILWAY FLATCARS**
A. Shimanovsky, I. Varazhun and A. Zavarotny

15:20 **ANALYSIS OF FRAMED STRUCTURES INCLUDING GENERALIZED WARPING EFFECTS**
E. Sapountzakis, I. Dikaros, A. Argyridi and St. Panos

15:40 **DYNAMIC FRICTION COEFFICIENT OF METALLIC FRACTURE INTERFACES WITH FRACTAL GEOMETRY**
O. Panagouli and K. Mastrodimou

16:00 **INFLUENCE OF STONES' SIZE ON THE COLLAPSE OF MASONRY BRIDGES**
B. Conde, G. Drosopoulos, B. Riveiro, M. Stavroulakis and G. Stavroulakis

16:20 **SIMULATION OF BOLT PRESTRESSING IN STEEL SHEAR CONNECTIONS**
St. Nasikas, D.-F. Kallias-Ntroumpis, A. Koukouselis and E. Mistakidis

Monday, July 13th **15: 00 - 16: 40**
Parallel Session D1-C2, Room 2

Mini-symposium 1-II (Films)
Organizers: D. Papageorgiou, V. Bontozoglou and N. Pelekasis
Chair: S. Kalliadasis, A. Papathanasiou

15:00 **MASS VARIATION OF A THIN LIQUID FILM DRIVEN BY AN ACOUSTIC WAVE**
W. Batson, Y. Agnon and A. Oron

16:20 **MOLECULAR DYNAMICS SIMULATION STUDY OF SINGLE DNA MONONUCLEOTIDES TRANSPORT THROUGH NANOSLITS**
K. Xia, B. Novak, D. Nikitopoulos and D. Moldovan

16:00 **BILAYER AND TRILAYER FLOW DOWN AN INCLINED PLANE IN THE PRESENCE OF SURFACTANT**
M. Blyth and J. Thompson

15:20 **CONTROLLING CHAOS IN THIN FILMS**
S. Gomes

15:40 **THE EFFECT OF SOLUBLE SURFACTANTS ON THE LINEAR STABILITY OF LIQUID FILM FLOW**
G. Karapetsas and V. Bontozoglou

Monday, July 13th **15: 00 - 16: 40**
Parallel Session D1-C3, Room 3

Computational Fluid Dynamics
Chair: K. Giannakoglou, Y. Kallinderis

15:00 **SIMULATING UNSTEADY INCOMPRESSIBLE FLOWS USING GALATEA-I, A PARALLEL MULTIGRID FINITE-VOLUME SOLVER**
S. Sarakinos, G. Lygidakis and I. Nikolos

15:20 **NUMERICAL SIMULATION OF OBLIQUE OSCILLATORY FLOW OVER BED RIPPLES USING THE IMMERSED BOUNDARY METHOD**
I. Chalmoukis and A. Dimas

15:40 **ADAPTIVE LOCAL HIGH-ORDER HYBRID GRIDS FOR FIELD COMPUTATIONS**
Y. Kallinderis, A. Karkoulias and P. Antonellis

16:00 **SHAPE OPTIMIZATION USING THE CONTINUOUS ADJOINT METHOD AND VOLUMETRIC NURBS ON A MANY GPU SYSTEM**
K. Tsiakas, X. Trompoukis, V. Asouti, M. Gh. Nejad and K. Giannakoglou

16:20 **LOWERING THE COST OF THE UNSTEADY ADJOINT METHOD FOR THE OPTIMAL FLOW CONTROL USING PULSATING JETS**
I. Kavvadias, Ch. Vezyris, E. Papoutsis-Kiachagias and K. Giannakoglou

16:40	**Break**

Monday, July 13th **16:50 - 18:30**
Parallel Session D1-D1, Room 1

Structural Mechanics II
Chair: K. Kaklis,S. Kourkoulis

16:50 **EXPERIMENTAL INVESTIGATION OF THE SIZE EFFECT ON THE MECHANICAL PROPERTIES ON TWO NATURAL BUILDING STONES**
K. Kaklis, S. Maurigiannakis, Z. Agioutantis, F. Stathogianni and E. Steiakakis

17:10 **THREE-DIMENSIONAL REINFORCED CONCRETE STRUCTURES SUBJECTED TO MAINSHOCK-AFTERSHOCK EARTHQUAKE SEQUENCES**
M. Hatzivassiliou and G. Hatzigeorgiou

17:30 **JOINING MARBLE STRUCTURAL ELEMENTS PART I: AN EXPERIMENTALLY VALIDATED NUMERICAL MODEL**
S. Kourkoulis, E. Pasiou and Ch. Markides

17:50 **DAMAGE ESTIMATION OF CEMENT MORTAR BEAMS UNDER THREE POINT BENDING LOADING USING ACOUSTIC EMISSIONS**
I. Stavrakas, D. Triantis and I. Dakanali

18:10 **THE CIRCULAR DISC WITH A RECTANGULAR HOLE**
Ch. Markides and S. Kourkoulis

Monday, July 13th **16:50 - 18:30**
Parallel Session D1-D2, Room 2

Mini-symposium 1-III (Capsules)
Organizers: D. Papageorgiou, V. Bontozoglou and N. Pelekasis
Chair: N. Pelekasis, A. Giannakopoulos

16:50 **MASS SPECTROMETRY BASED APPROACHES FOR THE STUDY OF DRUG DELIVERY AND BIODISTRIBUTION: APPLICATIONS IN DRUG DISCOVERY AND DEVELOPMENT PROGRAMS**
Th. Karampelas and C. Tamvakopoulos

17:10 **IS THERE A FUTURE FOR ULTRASOUND CONTRAST IMAGING?**
V. Sboros

17:30 **NUMERICAL STUDY OF THE INTERACTION BETWEEN AN ENCAPSULATED MICROBUBBLE AND A RIGID WALL IN A VISCOUS FLOW**
M. Vlachomitrou and N. Pelekasis

17:50 **ACOUSTIC INTERACTION BETWEEN A COATED MICROBUBBLE AND A RIGID BOUNDARY**
K. Efthymiou and N. Pelekasis

18:10 **STATIC RESPONSE OF COATED MICROBUBBLES: MODELLING SIMULATIONS AND PARAMETER ESTIMATION**
A. Lytra, N. Pelekasis, V. Zafiropoulou, Th. Zisis, A. Giannakopoulos, V. Sboros, E. Glynos and V. Koutsos

Monday, July 13th **16:50 - 18:30**
Parallel Session D1-D3, Room 3

Computational Analysis of Structures
Chair: G. Stavroulakis, A. Papadopoulos

16:50 **OPTIMISATION OF HIGH STRENGTH STEEL PRESTRESSED TRUSSES**
M. Gkantou, M. Theofanous and C. Baniotopoulos

17:10 **NUMERICAL ANALYSIS OF THE DISC-JAW INTERFACE DURING THE STANDARDIZED IMPLEMENTATION OF THE BRAZILIAN-DISC TEST**
S. Kourkoulis, Ch. Markides and P. Chatzistergos

17:30 **NUMERICAL MODELLING OF WELDED CONNECTIONS OF WIND TURBINE TOWERS UNDER FATIGUE LOADING**
N. Stavridou, E. Efthymiou and Ch. Baniotopoulos

17:50 **STATIC AND STABILITY ANALYSIS OF GRADIENT ELASTIC BEAMS BY FINITE ELEMENTS**
I. Pegios, S. Papargyri-Beskou and D. E. Beskos

18:10 **NUMERICAL EVALUATION OF ROTATIONAL CAPACITY OF STEEL BEAMS AT ELEVATED TEMPERATURES**
S. Akritidis, D. Pantousa and E. Mistakidis

18:30 **Coffee Break**

Monday, July 13th **18:30 - 19:30**

Session D1-E0, Papastratos Complex - Tholos

Poster Session

1. **CLOUD ON THE HORIZON: HIGH SPEED DROPLET IMPACT, SPREADING AND THIN FILM DYNAMICS**
   R. Cimpeanu, D. Papageorgiou, M. Kravtsova and A. Ruban
2. **NONLOCAL FREQUENCY ANALYSIS OF A NANOBEAM UNDER AXIAL MAGNETIC FIELD USING FINITE ELEMENT METHOD**
   M. Cajić, M. Lazarevic and D. Karličić
3. **NONLINEAR CYCLIC BEHAVIOR OF CIRCULAR CONCRETE-FILLED STEEL TUBES**
   D. Serras, K. Skalomenos, G. Hatzigeorgiou and D. E. Beskos
4. **JOINING MARBLE STRUCTURAL ELEMENTS PART II: A STEP TOWARDS OPTIMIZING THE SHAPE OF CONNECTORS**
   E. Pasiou and S. Kourkoulis
5. **LINEAR AND GEOMETRICALLY NONLINEAR ANALYSIS OF IN-PLANE THIN SHALLOW ARCHES**
   G. Tsiatas and N. Babouskos
6. **THE EFFECT OF SELECTED CASES OF LOADING ON THE VALUE OF FORCES IN THE MUSCLES LIFTING THE MANDIBLE**
   P. Stróżyk and A. Szust
7. **SEISMIC TESTING & DYNAMIC CHARACTER ANALYSIS OF HIGH-RISE BUILDING STRUCTURE IN CRETE BASED ON FEM**
   M. Koliou, E. Variantza, E. Kaselouris, I. Papadopoulos and V. Dimitriou
8. **CAD/FEM SIMULATION OF THE GOVERNING MECHANICS OF DRY TURNING**
   Th. Papadoulis, E. Variantza, E. Kaselouris and V. Dimitriou
9. **NUMERICAL MODELING OF PIEZOELECTRIC TORSIONAL VIBRATION TRANSDUCERS WITH TWISTED ELEMENTS**
   A. Nasedkin, S. Muzyka and E. Yuchutina
10. **SOME FINITE ELEMENT APPROACHES FOR MODELING OF ANISOTROPIC THERMOELASTIC MIXTURE AND PERIODIC COMPOSITES WITH INTERNAL MICROSTRUCTURE**
    A. Nasedkin, A. Nasedkina, A. Rajagopal and V. Remizov
11. **IN-SITU STRESS ESTIMATION IN OFFSHORE EASTERN MEDITERRANEAN WITH FINITE ELEMENT ANALYSIS**
    A. Kyriacou, P. Papanastasiou and E. Sarris
12. **THE MECHANICAL PROPERTIES OF POZZOLANIC LIME MORTARS USED AS FILLER MATERIAL IN THE RESTORATION OF ANCIENT MONUMENTS**
    Z. Agioutantis, S. Agalaniotou, S. Maurigiannakis and K. Kaklis

Tuesday, July 14th 2015
Papastratos Complex - Tholos

8:00-9:00 **Registration Desk Open**

Tuesday, July 14th **9:00-10:00**
Papastratos Complex Room 1

9:00 Plenary Lecture #2
Chair: G. Stavroulakis

G. A. Holzapfel
Trends in computational biomechanics: recent developments and future challenges

Tuesday, July 14th **10:00 - 11:40**
Parallel Session D2-A1, Room 1

Mini-symposium 2-I (Uncertainty Quantification)
Organizers: C. Papadimitriou, E. Chatzi
Chair: E. Chatzi, G. Stefanou

10:00 **UNCERTAINTY QUANTIFICATION IN EVOLUTIONARY POWER SPECTRUM ESTIMATION SUBJECT TO MISSING DATA**
L. Comerford, I. Kougioumtzoglou and M. Beer

10:20 **MODELLING CELLS USING APPROXIMATE BAYESIAN COMPUTATION**
G. Tauriello, E. A. Economides, P. Angelikopoulos, L. Kulakova, S. Wu, J. Sukys, P. Hadjidoukas and P. Koumoutsakos

10:40 **IDENTIFICATION AND FINITE ELEMENT MODEL UPDATING OF A LIGHT-WEIGHT GEOMETRICALLY COMPLEX STRUCTURE**
D. Giagopoulos and A. Arailopoulos

11:00 **UNCERTAINTY IN LOAD MEASUREMENTS OF WIND TURBINES**
D. Lekou and F. Mouzakis

11:20 **EFFECT OF SUPPORT CONDITIONS ON ESTIMATING HANGER TENSION IN ARCH BRIDGES USING MODAL FREQUENCY MEASUREMENTS**
K. Giakoumi, C. Papadimitriou, C. Argyris, L. Spyrou and P. Panetsos

Tuesday, July 14th **10:00 - 11:40**
Parallel Session D2-A2, Room 2

Mini-symposium 3-I (Non-Newtonian Flows – Viscoplastic Flows)
Organizers: J. Tsamopoulos, G. Georgiou
Chair: E. Mitsoulis, P. Saramito

10:00 **A NEW LOG-CONFORMATION FORMULATION FOR VISCOELASTIC FLUIDS**
P. Saramito

10:20 **LINEAR STABILITY OF VISCOELASTIC JETS AND STOKES LAYERS**
P. Ray, D. Papageorgiou and T. Zaki

10:40 **VISCOPLASTIC MODELLING OF GRANULAR COLUMN COLLAPSE WITH PRESSURE DEPENDENT RHEOLOGY**
I. Ionescu, A. Mangeney, F. Bouchut and O. Roche

11:00 **CESSATION OF VISCOPLASTIC POISEUILLE FLOW IN A RECTANGULAR DUCT WITH WALL SLIP**
Y. Damianou, G. Kaoullas and G. Georgiou

11:20 **VISCOPLASTIC FLOW IN A PERIODICALLY DRIVEN ANNULAR CAVITY**
A. Syrakos, Y. Dimakopoulos, G. Georgiou and J. Tsamopoulos

Tuesday, July 14th **10:00 - 11:40**
Parallel Session D2-A3, Room 3

Plasticity
Chair: N. Aravas, Th. Zisis

10:00 **ASSESSMENT OF THE UNDER-GROUND WATER LEVEL EFFECTS ON THE NONLINEAR BEHAVIOR OF SINGLE PILE SUBJECTED TO STATIC VERTICAL LOADS IN THE PRESENCE OF SOIL-PILE INTERACTION**
H. Khakpour Moghaddam, M. I. Khodakarami and D.-P. N. Kontoni

10:20 **STRESS AND STRAIN FLUCTUATIONS IN PLASTIC DEFORMATION OF CRYSTALS WITH DISORDERED MICROSTRUCTURE**
O. Kapetanou, M. Stricker, D. Weygand and M. Zaiser

10:40 **A HYSTERETIC MODEL FOR STEEL UNIAXIAL CYCLIC BEHAVIOR USED IN FRAME ANALYSIS**
I. Gkimousis and V. Koumousis

11:00 **CYCLIC PLASTICITY MODELING FOR THE FINITE ELEMENTS ANALYSIS OF STEEL PIPELINE INTEGRITY**
G. Chatzopoulou and S. Karamanos

11:20 **NON-LINEAR HOMOGENIZATION METHODS FOR THE CONSTITUTIVE MODELING OF MULTIPHASE STEELS**
I. Papadioti, K. Danas and N. Aravas

11:40 Coffee Break

Tuesday, July 14th **12:00 - 13:40**
Parallel Session D2-B1, Room 1

Mini-symposium 2-II (Uncertainty Quantification)
Organizers: C. Papadimitriou, E. Chatzi
Chair: I. Kougioumtzoglou, G. Kallos

12:00 **FRAGILITY ANALYSIS OF HYSTERETIC MDOF STRUCTURAL SYSTEMS SUBJECT TO EVOLUTIONARY STOCHASTIC EXCITATIONS**
I. P. Mitseas, I. A. Kougioumtzoglou and M. Beer

12:20 **A NEW DAMAGE-HEALING SMOOTH HYSTERETIC FORMULATION FOR THE MODELING OF SELF-HEALING MATERIALS**
S. Triantafyllou and M. Chatzis

12:40 **QUANTIFYING EXTREME WIND AND UNCERTAINTIES FOR ENERGY APPLICATIONS**
P. Patlakas, G. Galanis and G. Kallos

13:00 **THE ROLE OF MICROSTRUCTURE UNCERTAINTY IN STOCHASTIC FINITE ELEMENT ANALYSIS**
G. Stefanou, D. Savvas and M. Papadrakakis

13:20 **TESTING THE COMPLEX NETWORKS FROM MULTIVARIATE TIME SERIES: APPLICATION TO TURBULENT FLOW**
A. Charakopoulos, Th. Karakasidis, P. Papanikolaou and A. Liakopoulos

Tuesday, July 14th — 12:00 - 13:40
Parallel Session D2-B2, Room 2

Mini-symposium 3-II (Non-Newtonian Flows-Molecular Dynamics)
Organizers: J. Tsamopoulos, G. Georgiou
Chair: J. Tsamopoulos, Th. Karakasidis

12:00 **DYNAMICS OF GRAPHENE BASED POLYMER NANOCOMPOSITES THROUGH DETAILED ATOMISTIC SIMULATIONS**
P. Bacova, A. Rissanou and V. Harmandaris

12:20 **PRIMITIVE PATH DYNAMICS, CONSTRAINT RELEASE AND CONTOUR LENGTH FLUCTUATIONS IN A MODEL POLYETHYLENE MELT: A FIRST PRINCIPLES, ATOMISTIC SIMULATION STUDY**
S. Anogiannakis, D. Theodorou and C. Tzoumanekas

12:40 **STRUCTURAL, CONFORMATIONAL, DYNAMIC AND TOPOLOGICAL PROPERTIES OF RING POLY(ETHYLE OXIDE) MELTS FROM MOLECULAR DYNAMICS SIMULATIONS AND COMPARISON WITH EXPERIMENTAL DATA**
D. Tsalikis, Th. Koukoulas, V. Mavrantzas and D. Vlassopoulos

13:00 **PREDICTION OF THE EFFECTIVE DIFFUSIVITY OF WATER INSIDE CNT-BASED PMMA MEMBRANES**
P. Mermigkis, D. Tsalikis and V. Mavrantzas

13:20 **ATOMISTIC SIMULATION OF PYRENE FUNCTIONALIZED α,ω-PMMA AS DISPERSING AGENT OF GRAPHENE FOR THE FABRICATION OF POLYMER NANOCOMPOSITES**
E. Skountzos, V. Mavrantzas and C. Tsitsilianis

Tuesday, July 14th — 12:00 - 13:40
Parallel Session D2-B3, Room 3

Flow Structure interaction I
Chair: A. Vakakis, A. Dimas

12:00 **VORTICAL DYNAMICS FOR BOUNDED SHEAR FLOWS PAST A ROTARY OSCILLATING CIRCULAR CYLINDER**
K.-W. Chang and J.-H. Chen

12:20 **PARTIAL WAKE STABILIZATION IN VORTEX INDUCED VIBRATIONS OF A SPRUNG CYLINDER WITH AN INTERNAL NONLINEAR ATTACHMENT**
R. Kumar Tumkur, A. Masud, A. J. Pearlstein, O. Gendelman, L. Bergman and A. Vakakis

12:40 **COUPLED HYDRODYNAMIC AND STRUCTURAL BEHAVIOR OF SPAR BUOY FLOATING WIND TURBINES USING FAST**
E. Karageorgopoulos and A. Dimas

13:00 **MECHANICS OF THE FLOW OVER A FLEXIBLE FENCE**
A. Tsipropoulos and E. Konstantinidis

13:20 **RESPONSE OF OFFSHORE STRUCTURES UNDER THE EFFECT OF REAL SEA STATES INCLUDING STRUCTURAL AND SOIL NONLINEARITIES**
K. Chatziioannou, V. Katsardi, A. Koukouselis and E. Mistakidis

13:40 **Lunch Break**

Tuesday, July 14th **14:40 - 16:20**
Parallel Session D2-C1, Room 1

Mini-symposium 2-III (Uncertainty Quantification)
Organizers: C. Papadimitriou, E. Chatzi
Chair: E. Chatzi, C. Papadimitriou

14:40 **STOCHASTIC REPRESENTATION OF BRIDGE STRUCTURAL DYNAMICS**
N. Petrou, M. Spiridonakos and E. Chatzi

15:00 **CONFIGURATIONAL ENTROPY MAPS FOR STEADY-STATE TWO-PHASE FLOWS IN PORE NETWORKS IMPLEMENTING THE DEPROF MODEL ALGORITHM**
M. S. Valavanides and T. Daras

15:20 **IMPLEMENTATION OF ELASTIC ENERGY RESPONSE SPECTRA SUSTAINABILITY MEASURES FOR THE PREDICTION OF DAMAGE POTENTIAL OF GROUND STRONG MOTION RECORDS**
P. Koliopoulos, E. Kirtas, G. Panagopoulos and E. Mouratidis

15:40 **LOCAL ADAPTATION TECHNIQUES FOR NUMERICAL ATMOSPHERIC AND WAVE PREDICTION MODELS BASED ON KALMAN FILTERS AND BAYESIAN MODELS**
G. Galanis, E. Papageorgiou, A. Liakatas and G. Kallos

16:00 **BAYESIAN IDENTIFICATION OF NONLINEAR MODELS OF SEISMICALLY ISOLATED STRUCTURES**
C. Argyris, P. Tsopelas and C. Papadimitriou

Tuesday, July 14th **14:40 - 16:20**
Parallel Session D2-C2, Room 2

Mini-symposium 3-III (Non-Newtonian Flows – Viscoelastic Flows and Slip Effects)
Organizers: J. Tsamopoulos, G. Georgiou
Chair: S. Naris, D. Tsalikis

14:40 **VISCOELASTIC SIMULATIONS WITH INTEGRAL MODELS AT EXTREMELY HIGH SHEAR RATES**
E. Mitsoulis

15:00 **THE IMPACT OF SLIP ON NANOCHANNEL FRICTION FACTOR**
F. Sofos, Th. Karakasidis and A. Liakopoulos

15:20 **EQUATION OF STATE BASED SLIP SPRING MODEL FOR ENTANGLED POLYMER DYNAMICS**
G. Megariotis, G. Vogiatzis and D. Theodorou

15:40 **SIMULATION OF VACUUM PUMPING SYSTEMS VIA MESOSCALE MODELING**
S. Naris, Ch. Tantos, D. Bakalis, A. Stamatis and D. Valougeorgis

16:00 **ON THE VELOCITY DISCONTINUITY AT A CRITICAL BUBBLE VOLUME WHEN IT RISES IN A VISCOELASTIC FLUID**
D. Fraggedakis, J. Tsamopoulos and Y. Dimakopoulos

Tuesday, July 14th **14:40 - 16:20**
Parallel Session D2-C3, Room 3

Flow Structure Interaction II
Chair: K. Belibassakis, S. Karamanos

14:40 **WIND TURBINE BLADES PARAMETRIC DESIGN USING GRASSHOPPER®**
K. Charalampous, G. Strofylas, G. Mazanakis and I. Nikolos

15:00 **ENCLOSING ELLIPSOID ESTIMATIONS OF VARIABLE ELASTIC STRESS DOMAINS IN THE SHAKEDOWN ANALYSIS OF OFFSHORE JACKET PLATFORMS**
O. Ioannou, L. Mavridis, K. Nikolaou and Ch. Bisbos

15:20 **MARINE PROPULSION IN WAVES BY FLAPPING-FOIL SYSTEMS**
K. Belibassakis

15:40 **A PROBABILISTIC APPROACH FOR FATIGUE DAMAGE ANALYSIS OF AN OFFSHORE WIND TURBINE**
D. Bilionis and D. Vamvatsikos

16:00 **NUMERICAL SIMULATION OF FLUID - STRUCTURE INTERACTION BETWEEN SEA WAVES AND A SPAR-BUOY WIND TURBINE PLATFORM**
G. Makrygiannis and A. Dimas

Conference Event

Tuesday, July 14th **16:30 - 17:00**
Papastratos Complex Main Entrance

Bus Departure for the Train Station at Kato Lechonia and Milies

Tuesday, July 14th **17:15 - 21:00**
Visit to Milies with the train.

Tuesday, July 14th **21:00**
Conference Dinner at Koropi

Wednesday, July 15th 2015

Wednesday, July 15th **9:00-10:00**
Papastratos Complex Room 1

9:00 Plenary Lecture #3
Chair: D. Papageorgiou

S. Kalliadasis
Complex dynamics in multiscale systems

Wednesday, July 15th **10:00 - 12:00**
Parallel Session D3-A1, Room 1

Dynamics of Structures
Chair: N. Macris, S. Natsiavas

10:00 **THE EFFECT OF THE ROTATIONAL INERTIA ON THE POST-UPLIFT DYNAMIC STABILITY OF FREE-STANDING ROCKING COLUMNS AND ARTICULATED FRAMES**
N. Makris
10:20 **CONTROLLED LAGRANGIANS AND ROBUST STABILIZATION OF A UNDERACTUATED MICROBEAM WITH ROTATING JOINT**
M. Tavallaeinejad, M. Khalghollah and M. Eghtesad
10:40 **FINITE ELEMENT INELASTIC ANALYSIS OF 3-D FLEXIBLE PAVEMENTS UNDER MOVING LOADS**
N. Beskou, G. Hatzigeorgiou and D. Theodorakopoulos
11:00 **EQUATIONS OF MOTION FOR MECHANICAL SYSTEMS SUBJECTED TO EQUALITY MOTION CONSTRAINTS**
S. Natsiavas and E. Paraskevopoulos
11:20 **SEISMIC RESPONSE AND DESIGN OF ARCHED STRUCTURES**
G. Tsiatas and M. Fragiadakis
11:40 **NEW DIRECT TIME INTEGRATION METHOD FOR THE SEMI-DISCRETE PARABOLIC EQUATIONS**
J. Katsikadelis

Wednesday, July 15th **10:00 - 11:40**
Parallel Session D3-A2, Room 2

Biomechanics
Chair: A. Giannakopoulos, V. Bontozoglou

10:00 **BIOMECHANICAL MODELLING AND SIMULATION OF SOFT TISSUES USING FRACTIONAL MEMRISTIVE ELEMENTS**
M. Lazarevic, M. Cajić and N. Djurović

10:20 **AN ANALYSIS OF THE DURABILITY OF MANDIBLE ANGLE OSTEOTOMY FOR VARIOUS CASES OF OSTEOSYNTHESIS**
A. Szust and P. Stróżyk

10:40 **MAGNETOHYDRODYNAMIC EFFECTS ON BLOOD FLOW IN AN ANEURYSMAL GEOMETRY**
M. Xenos, A. Raptis and M. Matsagkas

11:00 **FINITE ELEMENT SIMULATION OF CAROTID ENDARTERECTOMY**
L. Spyrou, A. Giannakopoulos, A. Athanasoulas and A. Giannoukas

11:20 **MODELING AIRFLOW AND PARTICLE TRANSPORT IN THE LUNGS**
S. Georgakakou, Ch. Dritselis, V. Bontozoglou, Z. Daniil and K. Gourgoulianis

Wednesday, July 15th **10:00 - 11:40**
Parallel Session D3-A3, Room 3

Compressible Flows
Chair: D. Valougeorgis, J. Ekaterinaris

10:00 **THREE DIMENSIONAL H/P ADAPTIVE DISCONTINUOUS GALERKIN METHOD FOR HIGH SPEED COMPRESSIBLE FLOWS**
K. Panourgias and J. Ekaterinaris

10:20 **AN IMPLICIT 3D FINITE-VOLUME SCHEME FOR FREE-SURFACE FLOWS WITH SHOCKWAVES**
A. Klonidis and J. Soulis

10:40 **MODELING OF RAREFIED HYPERSONIC FLOWS USING THE MASSIVELY PARALLEL DSMC KERNEL "SPARTA"**
A. Klothakis and I. Nikolos

11:00 **THE DISCONTINUOUS GALERKIN METHOD FOR PARTIALLY IONIZED GAS COMPRESSIBLE FLOWS UNDER THE INFLUENCE OF ELECTROMAGNETIC FIELDS**
K. Panourgias and J. Ekaterinaris

11:20 **THERMALLY DRIVEN GAS FLOWS IN CAVITIES FAR FROM LOCAL EQUILIBRIUM**
G. Tatsios, D. Valougeorgis and S. Stefanov

12:00 **Coffee Break**

Wednesday, July 15th **12:20 - 14:20**
Parallel Session D3-B1, Room 1

Applied Numerical Solids
Chair A. Korlos, G. Tsiatas

12:20 **REINFORCED CONCRETE STRUCTURES STRENGTHENED BY CABLE ELEMENTS UNDER MULTIPLE EARTHQUAKES: A COMPUTATIONAL APPROACH**
A. Liolios and C. Chalioris

12:40 **A FEM STUDY ON THE INFLUENCE OF THE GEOMETRIC CHARACTERISTICS OF METALLIC FILMS IRRADIATED BY NANOSECOND LASER PULSES**
E. Kaselouris, E. Skarvelakis, I. Nikolos, G. Stavroulakis, Y. Orphanos, E. Bakarezos, N. Papadogiannis, M. Tatarakis and V. Dimitriou

13:00 **REUSE OF STONE MASONRY BUILDINGS AND THE SEISMIC BEHAVIOR OF THE COMPOSITE STRUCTURES**
E. Tavlopouloy, I. Tziveleka and M. Stavroulaki

13:20 **NUMERICAL MODELING OF THE FRICTION STIR WELDING PROCESS**
G. Papazafeiropoulos and A.-M. Tsainis

13:40 **COMPARISON OF MONOPILE VS TRIPOD FOUNDATION OF FIXED OFFSHORE WIND TURBINES VIA ADNANCED NUMERICAL ANALYSIS**
G. Margariti, A. Papadopoulos, C. Gantes and C. Gkologiannis

14:00 **NUMERICAL SIMULATION OF FLANGE-BOLT INTERACTION IN WIND TURBINE TOWER CONNECTIONS**
A. Ntaifoti, K. Koulatsou and C. Gantes

Wednesday, July 15th **12:20 - 14:00**
Parallel Session D3-B2, Room 2

Flow Stability-Transition
Chair: D. Papavassiliou, S. Yantsios

12:20 **TURBULENT FLOW USED TO SEPARATE PARTICLES OF DIFFERENT SCHMIDT NUMBERS**
D. Papavassiliou and Q. Nguyen

12:40 **FLOW FIELD INVESTIGATION AND VORTEX BREAK-DOWN IDENTIFICATION ON A DELTA WING USING URANS WITH SECOND MOMENT CLOSURE TURBULENCE MODELLING**
D. Komnos, Z. Vlahostergios and K.Yakinthos

13:00 **OPTIMAL CONTROL OF VORTEX SHEDDING USING DETAILED MODELS**
I. Bonis, H. Sarimveis and D. Koubogiannis

13:20 **VORTEX SHEDDING ENHANCEMENT FOR ENERGY HARVESTING APPLICATIONS IN MINIATURE DEVICES**
D. Koubogiannis and I. Bonis

13:40 **TRACING AXISYMMETRIC AND NON AXISYMMETRIC STATES IN CHEMICAL VAPOR DEPOSITION REACTORS**
P. Giannatselis, N. Cheimarios, E. Koronaki and A. Boudouvis

Wednesday, July 15th **12:20 - 14:20**
Parallel Session D3-B3, Room 3

Applied CFD I
Chair: P. Papanastasiou, J. Soulis

12:20 **INFLUENCE OF OBSTACLES ON THE DEVELOPMENT OF GAS EXPLOSION IN ROOM**
I. Polandov, V. Babankov and S. Dobrikov

12:40 **CO2 INJECTION FOR GEOLOGICAL STORAGE**
E. Sarris, E. Gravanis and P. Papanastasiou

13:00 **COMPUTATIONAL FLOW ANALYSIS AND DEVELOPMENT OF A SURROGATE MODEL FOR THE PREDICTION OF THE FLUID FLOW AND THE 3D FLOW EFFECTS AROUND A PROPELLER**
Ch. Salpingidou, D. Misirlis and K. Yakinthos

13:20 **A MULTI-CHANNEL MATHEMATICAL MODEL FOR PARTIALLY FAILED DIESEL PARTICULATE FILTERS**
O. Haralampous and D. Mastellos

13:40 **ON THE INTEGRATION OF EQUATIONS OF MOTION: FEM AND MOLECULAR DYNAMICS PROBLEMS**
E. Kakouris and V. Koumousis

14:00 **A MODELING STUDY FOR THE PIN-ASSISTED PULTRUSION OF POROUS SUBSTRATES**
N. Polychronopoulos and Th. Papathanasiou

14:20 **Lunch Break**

Wednesday, July 15th **15:40 - 17:40**
Parallel Session D3-C1, Room 1

Computational Mechanics & Dynamics of Structures
Chair: E. Mistakidis, V. Koumousis

15:40 **FINE TUNING OF FUZZY CONTROLLERS FOR VIBRATION SUPPRESSION OF SMART PLATES USING PARTICLE SWARM OPTIMIZATION**
G. Tairidis, G. Foutsitzi, P. Koutsianitis and G. Stavroulakis,

16:00 **INFLUENCE OF THE BOUNDARIES IN IMAGING FOR DAMAGE LOCALIZATION IN 1D DOMAINS**
Ch. Tsogka, Y. Petromichelakis and Ch. Panagiotopoulos

16:20 **SEMI SUPERVISED IDENTIFICATION OF NUMERICALLY SIMULATED PILE DEFECTS USING GRAPH LABEL PROPAGATION**
E. Protopapadakis, M. Schauer, A. Doulamis, G. Stavroulakis, J. Bohrnsen and S. Langer

16:40 **CAPACITY CURVE OF FERROCEMENT CYLINDER UNDER AXIAL LOADING**
A. Koukouselis and E. Mistakidis

17:00 **FRACTURE OF LIGHTWEIGHT STRUCTURES BASED ON A COMBINATION OF ENERGY RELEASE RATE BALANCE AND A COHESIVE LAW**
E. Theotokoglou and I. Tourlomousis

17:20 **THE MAEM FOR THE DYNAMIC ANALYSIS OF CYLINDRICAL SHELL PANELS**
A. Yiotis and J. Katsikadelis

Wednesday, July 15th **15:40 - 17:50**
Parallel Session D3-C2, Room 2

Conferment of the Award of the Best 2014 PhD Thesis
Chair: G. Stavroulakis, M. Papadrakakis

15:40 **STRUCTURAL OPTIMIZATION DESIGN OF WIND TURBINE TOWER USING GAME THEORY**
A. Kampitsis, G. Panagiotakopoulos, V. Koumousis and E. Sapountzakis

16:00 **BAYESIAN UPDATING WITH SUBSET SIMULATION AND NEURAL NETWORKS**
D. Giovanis, I. Papaioannou, V. Papadopoulos and D. Straub

16:20 **A STOCHASTIC FRAMEWORK FOR THE SEQUENTIALLY LINEAR ANALYSIS OF STRUCTURES WITH SOFTENING MATERIALS**
M. Georgioudakis , G. Stefanou and M. Papadrakakis

16:40 **A DISPLACEMENT BASED FORMULATION FOR CRACK PROBLEMS IN COUPLE STRESS ELASTICITY**
K. Baxevanakis, H. Georgiadis and P. Gourgiotis

17:00 **EFFICIENT ASSEMBLY OF GAUSS QUADRATURE-BASED MATRICES**
A. Karatarakis and M. Papadrakakis

17:20 **EFG VS FEM: ACCURACY AND COST EFFICIENCY**
P. Metsis, A. Karatarakis and M. Papadrakakis

17:40 Conferment of the GRACM Award of the Best 2014 PhD Thesis to Dr. M. Georgioudakis

Wednesday, July 15th **15:40 - 17:20**
Parallel Session D3-C3, Room 3

Applied CFD II
Chair: Th. Papathanasiou, K. Yakinthos

15:40 **PECULIARITIES OF THE LIQUID CARGO DYNAMICS MODELING FOR THE CASE OF ROAD TANK TRANSIENT MOVEMENT MODES**
M. Kuzniatsova, A. Shimanovsky and A. Sapietová

16:00 **STEAMING HEAT COILS FOR HEATING UP MARINE HEAVY FUEL OIL**
G. Gavriil, G. Prodromidis, F. Coutelieris

16:20 **THREE DIMENSIONAL WATER FLOW IN NOZZLES**
J. Soulis and M. Loukas

16:40 **NUMERICAL SIMULATION OF LNG EVAPORATION INSIDE SEMI-TRAILER TRUCKS USED FOR THE TRANSPORTATION OF LNG TO SMALL SCALE TERMINALS AND REFUELLING STATIONS: PARAMETERS AND IMPLICATIONS**
K. Rossios, K. Sardi and G. Martinopoulos

17:00 **A CFD-AIDED DESIGN PROCEDURE, PERFORMANCE ESTIMATION AND OPTIMIZATION STUDY OF A MALE UAV**
P. Panagiotou, Ch. Salpingidou, P. Kaparos and K. Yakinthos

17:50	**Coffee Break**

Wednesday, July 15th **18:00 - 18:30**
Session D3-D0, Papastratos Complex - Tholos

Poster Session

18:30	**Congress Closing**

European Union
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OPERATIONAL PROGRAMME
EDUCATION AND LIFELONG LEARNING
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