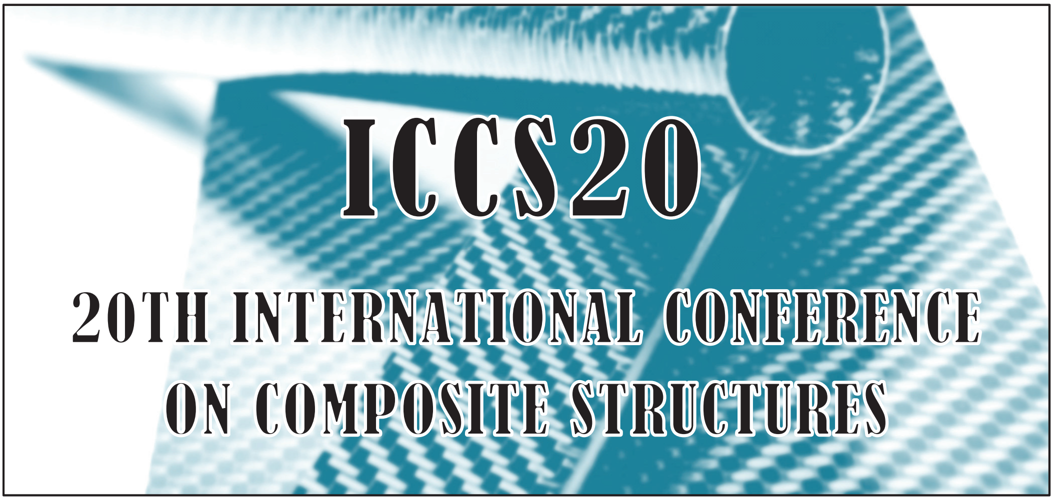

Conservatoire national des arts et métiers, Paris, France
4-7 September 2017

PROCEEDINGS

CONFERENCE CHAIRS
Antonio J.M. Ferreira, University of Porto, Portugal
Walid Larbi, CNAM, Paris, France
Jean-François Deu, CNAM, Paris, France
Francesco Tornabene, University of Bologna, Italy
Nicholas Fantuzzi, University of Bologna, Italy

LOCAL ORGANIZING COMMITTEE
Michele Bacciocchi, University of Bologna, Italy

SOCIETÀ EDITRICE ESCULAPIO

STRUCTURAL AND COMPUTATIONAL MECHANICS BOOK SERIES

ISSN 2421-2822
ISBN 978-889-385-041-4
DOI 10.15651/978-88-938-5041-4

First edition: August 2017

Publishing Manager: Alessandro Parenti
Editorial Staff: Giancarla Panigali, Laura Tondelli

SOCIETÀ EDITRICE ESCULAPIO

40131 Bologna - Via U. Terracini 30 - Tel. 051-63.40.113 - Fax 051-63.41.136
www.editrice-esculapio.it

uniaxial, biaxial and triaxial unitary stretch, which is done thanks to an application of the FEM system ABAQUS with its 20-noded brick and 10-noded tetrahedral solid finite elements [3]. The entire series of solutions is numerically available in the SFEM context upon application of the Response Surface Method (RSM) [2], where optimized multivariate polynomial approximations of the homogenized tensor components are recovered in the system MAPLE thanks to the Least Squares Method (LSM). The RSM is further applied to determine the additional multivariate polynomial representations of the effective elasticity tensor components with respect to random volumetric void ratio in the interphase. It is necessary to mention that this void ratio is assumed as Gaussian with the given expectations and some intervals of the admissible stochastic fluctuations (coefficients of variation smaller or equal than 0.20 each time). We investigate numerically (1) if the resulting homogenized characteristics are also Gaussian, (2) how the inhomogeneous spatial distribution (and clustering) of particles affects the effective stiffness tensor and (3) an effect of rising void ratio in the interphase in the context of probabilistic analysis. We determine expected values, coefficients of variation, skewness and kurtosis for all available components of the effective elasticity tensor in 3D homogenization problems– all as functions of the coefficient of random dispersion for the input random parameter (void ratio). Probabilistic method engaged to this computation is triple – contains the generalized stochastic perturbation technique of the optimized order, Monte Carlo simulation as well as semi-analytical technique implemented in the symbolic computer program consisting in direct determination of probabilistic characteristics from their integral. Optimization of the RSM polynomial order is done via simultaneous maximization of correlation and minimization of LSM error and variance. Further SFEM computational studies will concern geometrical parameters of the interphase and its impact on the effective parameters of the polymer-based composites and also numerical simulation of the RVE with matrix and an interphase in its hyper-elastic regime.

Acknowledgements: The Authors would like to acknowledge the research grant 2016/21/N/ST8/01224 from National Science Centre in Cracow, Poland.

References

[1] L. Daridon, Y. Chemisky, C. Licht, S. Orankitjaroen, S. Pagano, Periodic homogenization for Kelvin-Voigt viscoelastic media with a Kelvin-Voigt viscoelastic interphase. European Journal of Mechanics – A/Solids, 58: 163-171, 2016.
[2] M. Kamiński, The Stochastic Perturbation Technique for Computational Mechanics, Wiley, Chichester, 2013.
[3] M. Kamiński, D. Sokołowski, Dual probabilistic homogenization of the rubber-based composite with random carbon black particle reinforcement. Composite Structures, 140: 783-797, 2016.

21 | Lower bound to the plastic collapse load of structural elements made of nanocomposites

Aurora Angela Pisano (aurora.pisano@unirc.it, University Mediterranea of Reggio Calabria, Italy)
Paolo Fuschi (University Mediterranea of Reggio Calabria, Italy)

Nanocomposite materials, for their better performance with respect to traditional composites, are emerging materials, widely employed in structural applications of industrial fields such as aeronautical and automotive. There is a growing literature concerning these materials, however, because of their constitutive complexity, the evaluation of the bearing capacity of structural elements made up with them is mainly pursued experimentally. In fact, the difficulties both in characterizing all the mechanical parameters of the material and in correctly describing its evolution up to collapse or within the post-elastic regime, makes problematic the application of well known numerical procedures, such those based on step by step analyses. In these cases, it may be more effective to follow a limit analysis approach that, even if in approximate way, can directly provide the bearing capacity of the addressed structural elements. On the other hand, it is worth noting that nanomaterials are inherently nonlocal, so a correct description of their constitutive behaviour can be obtained only by means of nonlocal models. The latters, making use of internal material parameters, can take into account, at macro-level, phenomena arising at micro- or nano-level. On the base of the above considerations, the paper proposes a limit analysis numerical procedure, known, in its original formulation, as elastic compensation method, but here rephrased in a nonlocal elastic context to evaluate the lower bound to the collapse load multiplier of structural elements made up of nanocomposites. The procedure, already utilized by the authors in different (local) contexts [1], makes use of sequences of elastic analyses in order to mimic the behaviour of the structure at collapse. In the nonlocal framework, here considered, the elastic analyses are nonlocal and performed by means of a nonlocal finite element code, implemented by the authors in [2]. A nonlocal elastic perfectly plastic constitutive model is assumed with the further hypothesis that the nonlocal behaviour pertains only to the elastic phase. The nonlocal elastic description is given by an enhanced version of the Eringen model, namely the strain-difference-based integral model [3]. The proposed formulation is tested by means of a case study. The obtained results are discussed with the aim to highlight advantages and drawbacks of the entire numerical approach.

References

[1] A.A. Pisano, P. Fuschi, D. De Domenico. Limit analysis on RC-structures by a multi-yield-criteria numerical approach, In: Direct Methods for Limit and Shakedown Analysis of Structures: advanced computational algorithms and material modeling 199-219.

Springer Int. Publishing Switzerland. 2015.
[2] P. Fuschi, A.A. Pisano and D. De Domenico. Plane stress problems in nonlocal elasticity: finite element solutions with a strain-difference-based formulation, Journal of Mathematical Analysis and Applications 431, 714-736, 2015.
[3] C. Polizzotto, P. Fuschi, A.A. Pisano. A strain-difference-based nonlocal elasticity model. Int. J. Solids Struct. (2004);41:2383-2401.

44 | A meshless analysis of composite plates considering high-order shear deformation theories and a layerwise theory

Daniel, E.S. Rodrigues (em11175@fe.up.pt, Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), University of Porto, Portugal)
Jorge, Belinha (Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), University of Porto, Portugal)
Aurélio, L. Araújo (Instituto Superior Técnico, University of Lisbon, Portugal)
António, J.M. Ferreira (Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), University of Porto, Portugal)
Lúcia, M.J.S. Dinis (Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), University of Porto, Portugal)
Renato, M. Natal (Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), University of Porto, Portugal)

Composite laminated plates find several structural applications, particularly in the aerospace field. Generally, these structures follow a laminated construction. This layout aims to take advantage of their specific direction-dependent mechanical properties, such as their high specific strength and specific elasticity modulus. In order to achieve a complete reliability on the design of composite laminates, they need to be modelled and simulated. Treating them as a 3D solid is not a practicable way to deal with complex geometries and arbitrary boundary conditions. Hence, simplified 2D models (equivalent single layer theories) were developed as an easier alternative. In this work the displacement field of the composite laminated plate is defined not only by equivalent single layer theories following different high-order shear deformation theories but also by a layerwise theory. The solutions obtained from the different plate models are compared for several composite laminates that were analysed and conclusions are drawn concerning the accuracy and computational cost of both models. This work considers a radial point interpolation (RPI) meshless method [1] as the numerical tool to obtain the solutions from the studied plate theories. In the end, the results obtained showed the efficiency and accuracy of the RPI meshless method.

Keywords: meshless methods, composite plates, layerwise theory, high-order shear deformation theories.
Acknowledgments: The authors truly acknowledge the funding provided by Ministério da Educação e Ciência – Fundação para a Ciência e a Tecnologia (Portugal), under grants SFRH/BPD/111020/2015, and by project funding UID/EMS/50022/2013 "Advanced materials for noise reduction: modeling, optimization and experimental validation" (LAETA inter-institutional projects). Additionally, the authors gratefully acknowledge the funding of Project NORTE-01-0145-FEDER-000022 – SciTech – Science and Technology for Competitive and Sustainable Industries, co-financed by Programa Operacional Regional do Norte (NORTE2020), through Fundo Europeu de Desenvolvimento Regional (FEDER).
References
[1] J. Belinha, Meshless Methods in Biomechanics - Bone Tissue Remodelling Analysis, Vol.16 ed. Lecture Notes in Computational Vision and Biomechanics, Springer Netherlands, 2014.

ANALYSIS OF COMPOSITE BEAMS, PLATES AND SHELLS

860 | Multi-layer composite beam modelling and optimization for high speed mechanical applications

Giuseppe, Catania (Alma Mater Studiorum University of Bologna, Italy)
Matteo, Strozzi (matteo.strozzi2@unibo.it, Alma Mater Studiorum University of Bologna, Italy)

Multi-layer composite beam applications are known and used to obtain functionally graded mechanical components whose properties can be tuned to obtain high performance, such as strength, stiffness, light inertia and damping behaviour. Nevertheless, the technical literature lacks in studies concerning multi-layer dynamical beam modelling making it possible to identify the model parameters of known solutions and to design new solutions being able to overcome the limits associated to such solutions. A current research topic concerns high damping FGM applications in the aerospace field, where standard high stiffness, high strength slender shell components, such as turbine blades, must show a limited vibrational behaviour in operating conditions, i.e. the material used should exhibit normally conflicting characteristics, such as high internal hysteresis and high stiffness as well. In this specific field, some recent applications were explored, mainly based on an experimental approach, and while