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INTERACTION OF APPLIED MATHEMATICS AND MECHANICS CONFERENCE IAMMC2017

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IAMMC 2017 INTRODUCTION, PROGRAM AND ABSTRACTS

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Parametric constitutive modelling of cancellous bone

PIOTR KOWALCZYK

Institute of Fundamental Technological Research, Polish Academy of Sciences (IPPT PAN), Warsaw, Poland
email: Piotr.Kowalczyk@ippt.pan.pl

Graduated from Warsaw University of Technology in 1986, received his PhD (1992) and habilitation (2007) degrees at Institute of Fundamental Technological Research, PAS, in Warsaw, Poland. Currently he is heading the Department of Computational Science at the institute. His main area of research interest is computational mechanics. He is an author and coauthor of 19 papers and 2 monographs devoted to design sensitivity analysis in nonlinear mechanics, computational methods in biomechanics and constitutive modelling of cellular materials.

Parametric constitutive models are models in which material properties at the macro scale (here – orthotropic elastic constants) are explicit functions of certain microstructural parameters. Such models are desired in e.g. optimization problems of material properties in which the most efficient gradient methods can be then used. In the case of cancellous bone, parametric constitutive models enable numerically efficient simulation of adaptive bone remodelling processes at the macro scale. Parametric constitutive models are constructed by homogenization of microstructural properties. This requires assumption of microstructure periodicity. In cancellous bone this assumption is problematic, however, observations indicate that there are some typical classes and patterns of microstructure geometry (like bars, plates or fenestrated cells) found in practically all human and animal bones [1]. This allows to define a repeatable microstructural unit described by 3 or 4 geometric parameters, corresponding in the macro scale to transversely isotropic or orthotropic material, respectively, that mimics with a good accuracy actual bone microstructure [2]. Mechanical properties of a homogenized material can be determined in a variety of numerical methods (e.g. FEM) for a particular set of parameter values. Repeating the computations for a sufficiently large number of different parameter values sets generates a database whose interpolation allows to determine macroscopic material properties for each arbitrary microstructure without the need to

perform another time-consuming numerical analysis of the homogenization problem.

Comparison of materialproperties of actual bone samples and the homogenized artificial microstructures proves good correspondence between each other.

REFERENCES

[1] Gibson L.J., Ashby M.F., *Cellular Solids: Structure and Properties.* Pergamon Press, 1988

[2] P. Kowalczyk, *Orthotropic properties of cancellous bone modelled as parameterized cellular material*, Computer Methods in Biomechanics and Biomedical Engineering, 9, 135–147, 2006