11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

A NOVEL APPROACH TO MULTISCALE HOMOGENISATION FOR 3D MICRO-STRUCTURES

Philippe G. Young[1] and David R. Raymont[2]

[1] College of Engineering, Mathematics and Physical Sciences, University of Exeter, Harrison Building, North Park Road, Exeter, EX4 4QF, United Kingdom, Philippe.G.Young@exeter.ac.uk and http://emps.exeter.ac.uk/engineering/staff/pgyoung

[2] Simpleware Ltd., Bradninch Hall, Castle Street, Exeter, EX4 3PL, United Kingdom, d.raymont@simpleware.com and http://www.simpleware.com

Key Words: *Homogenisation, Material Characterisation, Elasto-statics.*

Synthetic and natural micro-architectures occur frequently (e.g. MMC foams, bone, etc.) and multiphase functionally graded composites are becoming increasingly popular for applications requiring optimised/tailored material properties. When dealing with such materials computationally, one issue which immediately arises is the analysis of the mechanical properties of macroscopically inhomogeneous multiscale structures.

The bulk response of these structures can be determined by performing a 'full' finite element analysis with the entire geometry discretised at a resolution high enough to accurately model the smallest length scale of interest. However, these full models may easily exceed hundreds of millions, potentially billions, of degrees of freedom, and solving problems of this magnitude may only be possible with the use of supercomputing facilities. In the present project, a novel two stage approach to solving such large problems by performing element by element homogenisation of the micro-structure followed by solving the global problem with a coarser mesh as outlined in Figure 1 was explored.

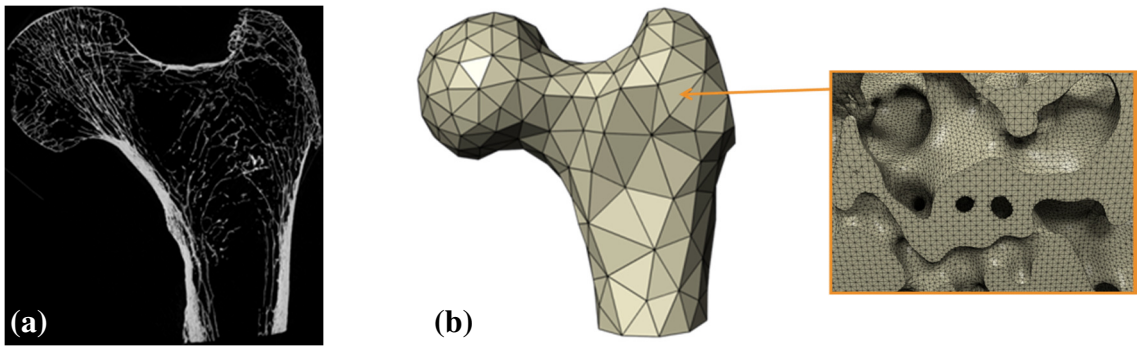

***Figure 1**: (a) High resolution scan of proximal femur (b) coarse tetrahedral finite element discretisation of femur-element properties are assigned based on finite element based homogenisation of tetrahedral sub domain.*

The approach taken effectively relies on creating a coarse tetrahedral/hexahedral discretisation of the domain using traditional volume meshing techniques, and assigning appropriate material properties obtained from a finite element homogenisation based on a high resolution mesh at the micro-structural level of the macro tetrahedra or hexahedra. In effect, two length scales are decoupled by computing effective properties using the finite element approach for each macro-element.

ACKNOWLEDGEMENT

The authors wish to thank the US Air Force Research Laboratories for their support for this project under the auspices of EOARDS grant FA8655-12-1-2087.