Advanced computing applications based on micro CT data

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1 Introduction

The macroscopic behavior of composite materials is governed by the microstructure and the material behavior of the phases. Micro Computed Tomography (μCT) is a modern non-destructive method for the production of high-resolution images of the studied specimen. Three-dimensional voxel images are reconstructed from a large number of digital radiographs (projections) of the imaged object, obtained at different projection angles.
The next important step is the segmentation of the resulting μCT data. Segmentation refers to the identification and labeling of different phases within the image. Common image processing tools for 3-D segmentation are spatial filtering, artifacts and noise removal, thresholding, morphological operations and cluster analysis. The result of the segmentation of a grayscale image is not unique and usually the segmentation algorithms require manual interaction [1].

Fig. 1. Industrial CT scanning system, part of AComIn SmartLab equipment [2].

The third important step in the study is to simulate physical processes in the segmented microstructure and to obtain volume-averaged physical property estimates. Various algorithms have been proposed over the last two decades for simulating the micro-scale physical processes and estimating macro-property values. Typical applications are related to effective elastic properties, permeability, conductivity, etc. A common approach is finite element or finite difference discretization of the underlying partial differential equations on a regular Cartesian grid, which is directly derived from the segmented voxel image.

2 Examples

2.1 Fiber reinforced composites

Fiber-Reinforced Self-Compacting Concrete belongs to the family of High-performance Concretes, which satisfies a requirement to overcome limitations of conventional concretes. Incorporation in concrete composition of steel fiber reinforcement with structural function increases the degree of ductility of typically brittle cement containing composites, which in some cases can replace completely or partially conventional steel reinforcement in the form of rods and meshes. Using the alternative methods to study such type of composite materials is an attempt to characterize the structure and mechanical properties of a wide range of building materials [4].

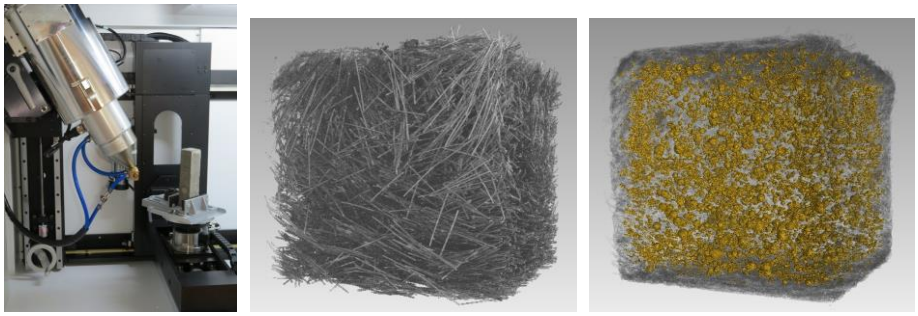

Fig. 2. Tested specimen (left), fiber distribution (center), porosity distribution (right).

2.2 Bone tissue

Micro CT is established as an essential tool for evaluating bone microstructure and and has been used to study metabolic bone diseases such as osteoporosis. Microstructural features obtained by μCT imaging, affords unique capabilities to evaluate local biomechanical behavior under complex loading conditions by finite

element analysis and high performance computing. This approach allows virtual recapitulation of experimental or physiologic boundary conditions to estimate local stresses and strains within a tissue of complex geometry [3].

Fig. 3. Digital X-ray image (projection) (left), reconstructed voxel image and vertical intersection (center, right)

References

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