Morphological and mechanical characterization of porous structures with µ-CT

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Porous structures like insulation materials, filter materials and stuffings, bone replacing materials and bone itself, have a quite big importance in our daily life. To be able to understand and to simulate the functional behaviour of these materials during loading, there is a great need for a thorough knowledge of the important relationship between the morphology and the mechanical behaviour.

To quantify the morphology of porous structures, microfocus X-ray computed tomography (µ-CT) is used. For the morphological characterisation of bone and porous structures that are used in medical applications, this technique is widely used. Validation with histology is well researched, but is in most cases however still looked at. For porous structures like cellular foams and geological samples, there is a lack of clear validation criteria. Also, when one wants to analyse porous materials with µ-CT, one needs to find the optimal acquisition parameters by 'trial and error', which is quite time consuming.

To optimise and to standardise the use of µ-CT on porous structures in general, this research wishes to develop a 'protocol' for image optimisation. This protocol will contain reference graphs that give indicative values for optimal acquisition parameters and recommendations for further image processing. This will be done for different porous materials, so that µ-CT will become a material-independent imaging technique. The optimal µ-CT images will then be validated. One of the validation techniques is slicing, combined with optical microscopy. Also some testing at random with high-resolution µ-CT and research on other possible validation techniques will be performed. Mathematical image analysis on the optimal µ-CT images will generate two sets of structural parameters, namely a basic and a detailed set. The basic set will contain a limited number of structural parameters, while the detailed set will contain extra parameters which dependent on the application of the porous structure. These sets will quantify the porous structures morphologically.

Based on the structural parameters or based on the µ-CT images, models will be created that describe the porous structures mechanically, in a theoretical way. To validate this theoretical, mechanical description, µ-CT under 'in situ' loading together with strain mapping and 'environmental scanning electron microscopy' (ESEM) will be used. The set-up for the µ-CT under 'in situ' loading is not yet available and will be developed during this research.