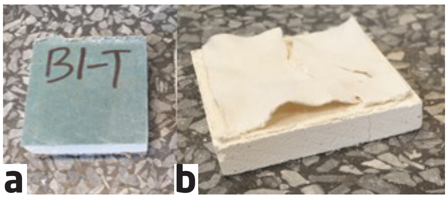
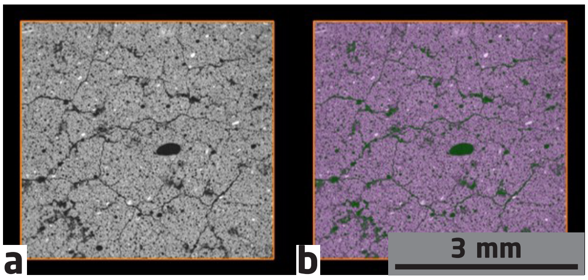
Investigation of gypsum after high temperature exposure

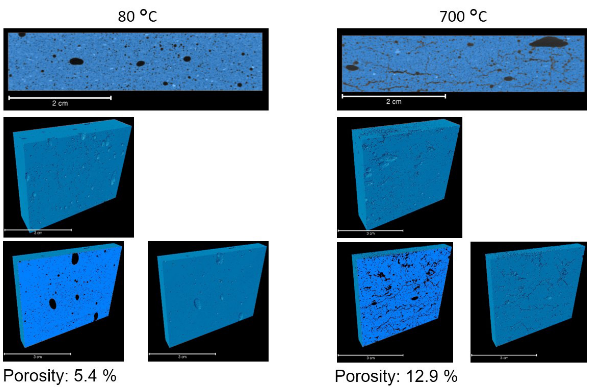
Danish Institute of Fire and Security Technology (DBI) specialises in fire testing, consulting, inspection, fire investigation and certification services. For the testing business of the company, the large scale fire tests are expensive to perform, but there is a significant interest in developing the prediction ability of their outcome so as to aid the product development for DBI's customer base. To predict a material's fire resistance, it is necessary to perform simulations with precise models that require the material's properties as input. For porous materials, the porosity, i.e. the amount of air in respect to total volume, plays an important role. One typical porous material found in building materials is gypsum, which contains pores with different size ranges. However, the porosity observed in the material depends on the temperature the material is exposed to. Therefore, DBI engaged with the 3D Imaging Centre at DTU to perform X-ray computed tomography measurements on gypsum plates exposed to different temperatures to determine their porosity and the influence of the porosity on the material properties used for simulations.



Gypsum plaster boards after exposure at a) 80 °C and b) 700 °C.



Slice of the gypsum treated at 700 °C a) before and b) after differenciation of air and gypsum. The air is colored in green while the gypsum is colored in violet.



Overlay of gypsum (blue) and air (black in the top and bottom left pictures, otherwise transparent) and calculated porosity.

Challenge

The porosity of materials is commonly determined by bulk analysis methods, e.g. by looking at how much of a specific gas or mercury is needed to fill the pore space of the studied material. In contrast, X-ray Computed Tomography (CT) offers a non-destructive imaging method which results in a 3D representation of the studied sample. Therefore, it allows to both visualise the material and study the pores and their connectivity, but at limited resolution.

Collaboration

Through the collaboration between DBI and the 3D Imaging Centre at DTU, the gypsum pieces were characterised using in-house X-ray CT. This collaboration was part of the LINX project, in which researchers at leading Danish universities collaborate with scientists in industry to solve industry relevant problems using advanced neutron and X-ray techniques. Besides performing projects for the members of the LINX association, the LINX project also supports outreach projects for companies which are not members of the LINX association. In this way, companies can test how they can profit from X-ray- and neutron-based techniques.

Results

A series of five gypsum samples exposed to temperatures ranging from 80 °C to 700 °C was studied using X-ray CT. Then, image analysis was used to differentiate between the air, in dark, and the gypsum, in bright. By that, the porosity (fraction of air in respect to the total volume) could be determined. With increasing temperature, an increase in porosity could be seen. In addition, the visual inspection of the scan revealed cracks in samples treated above 300 °C.

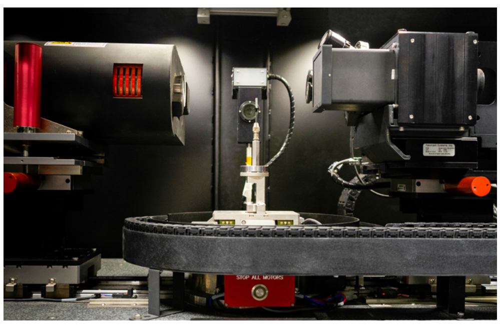
Perspectives

Here, only the porosity was used as an input to the simulation, but the approach also allows incorporating the actual geometry of air within the sample, which could lead to more accurate simulations.

Imaging Industry Portal

The Imaging Industry Portal is a part of the 3D Imaging Centre at DTU and assists companies in using and implementing 3D Imaging in research, development and production. The portal offers research-based 3D Imaging services and provides companies with the latest equipment and the most advanced knowledge within 3D Imaging and data analysis. The Imaging Industry Portal works as a gateway to ESS and MAX IV, as well as other large scale facilities.

www.imaging.dtu.dk/Industry-Portal



DTU 3D Imaging Centre