3D detection and characterization of damage in quasi-brittle heterogeneous materials

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Abstract

Detailed experimental characterization of cracking under mechanical loading is necessary to understand damage in many quasi-brittle materials, whose mechanical description is still an open issue. Moreover, it is required for the development, the identification and/or the validation of 3D damage models. Such a characterization is made available through X-Ray Computed Tomography (XRCT), making possible the direct observation of crack networks within the material under in situ mechanical loading. In order to quantify the precise location and the extension of micro-cracks, and to detect early-age cracking, a method based on Digital Volume Correlation (DVC) has been developed. After running DVC routines, the difference between the deformed image (containing cracks) and the reference image (without cracks) is computed. This so-called "subtracted image" reveals the path of cracks which is clearly visible. Segmentation of cracked areas is thus possible, while it would have been very difficult to extract them from the heterogeneous microstructure in the deformed XRCT images. Moreover, very tiny cracks can also be detected and their sub-voxel opening evaluated. This DVC-assisted subtraction has been used to analyze the crack network and its evolution in lightweight concrete, lightweight plaster and SiC/SiC composite tubes. In situ compressive tests on lightweight concrete and plaster were performed on the XRCT laboratory scanner available at Laboratoire Navier. Because of very small crack openings, synchrotron XRCT (PSICHE beamline, SOLEIL) was necessary to characterize damage in SiC/SiC composites tubes under in situ tensile loading.

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