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THE ROLE OF KINEMATIC BOUNDARY CONDITIONS AND THEIR (IN)ACCURACY IN MICROMECHANICAL PARAMETER IDENTIFICATION

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Abstract. In this study, effects of inaccuracy in Dirichlet boundary conditions prescribed to a micromechanical model used in Integrated Digital Image Correlation are examined. It is shown that relatively small errors, stemming typically from an underlying Digital Image Correlation, may yield significant errors in the identified material parameters.

Since its introduction, Integrated Digital Image Correlation (IDIC) has proven to be a reliable and accurate full-field measurement technique for the identification of constitutive parameters. It relies on the minimization of the difference between two images captured during an experiment, one image corresponding to the reference and the other to back-deformed configuration. The back-deforming displacement field is usually obtained from an underlying mechanical model. In cases in which the Boundary Conditions (BCs) applied to a measured specimen lie outside of the field of view, IDIC suffers from inaccuracy. This situation applies by definition also to the case of micromechanical parameter identification, as images are typically obtained by electron microscopy or other microscopy techniques whereas the loads are applied at a much larger scale. Several approaches have been proposed and tested in the literature that attempt to resolve this issue, cf. e.g. [1]. So far the most accurate one employs Global Digital Image Correlation (GDIC) in order to identify the displacements that are subsequently applied as boundary conditions to the Microstructural Volume Element (MVE) associated with IDIC.

It has been reported in the literature, cf. e.g. [2], that in general DIC on the one hand lacks kinematic freedom when large elements are used (kinematic smoothing), but on the other hand suffers from random errors when small elements are used. Because the BCs are kept fixed during IDIC procedure, any errors introduced through them remain
locked. The only way in which the MVE can compensate for erroneous BCs is by adjusting material parameters—hence resulting in inaccurate identification of those parameters.

In the present study we focus on quantifying the effects of inaccuracies in the prescribed BCs on the accuracy of the identification in a systematic way by means of virtual experiments. Fig. 1 shows preliminary results obtained for shear and bending tests of a rectangular specimen under plane strain conditions. The specimen consists of a soft rubber matrix with circular inclusions having a material contrast ratio of 4. The figure shows that identified parameters rapidly deviate from 1 with increasing GDIC mesh element size. More importantly, a similar behaviour can be observed for decreasing element size, especially in the case of bending. Because the trends of Fig. 1 can be observed also for the remaining combinations of identified material parameters, it may be concluded that the GDIC mesh and errors locked in the MVE boundary are crucial for ensuring the accuracy of the IDIC procedure. A method with improved accuracy is currently being developed.

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