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THE EFFECT OF INCLUSION SPATIAL DISTRIBUTION: MODELLING AND EXPERIMENTAL VALIDATION

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The classical mean-field models are not sensitive to the space distribution of components within the representative volume element of heterogeneous material. Such effect can be accounted for by applying the extensions of the standard scale transition schemes by using either morphologically representative pattern (MRP) approach [1] or the interaction 'cluster' model [2]. According to the first model the inclusion packing effect is described by introducing a coating to the particle, equal to the half of mean minimum distance between inclusions in the representative volume. On the other hand the cluster model accounts for the interaction between each of two particles in the predefined cluster volume. For isotropic phases the MRP predictions are also isotropic, whereas for the cluster model the geometry of particle distribution is reflected in the anisotropic effective properties. The availability of such a modelling tool enables the selection of optimal microstructure in the material-by-design strategy.

To validate those proposals the numerical homogenization of representative cells is usually performed. Another possibility is to compare model predictions with the experimental data, although in such direct comparison we often cannot decouple the two effects: the proper recognition of the material model for a single phase and the scale transition rule. In our recent studies we performed tests on samples made of epoxy resin with a predefined distribution of spherical voids and varying volume fraction. The samples were prepared using a 3D printing technique [3]. The samples with regular cubic, body centre cubic and face centre cubic distributions of spherical voids were printed. They were tested in the regime of strain enabling to obtain elastic stiffness. DIC technique were used to measure material response under compression. As a reference the sample without voids was also printed and subject to testing. Anisotropy of the response related to both, printing direction and geometry of void placement was assessed. Acceptable accordance with mean-field models was found during testing.

The research was partially supported by the project No. 2016/23/B/ST8/03418 of the National Science Centre, Poland.

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