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► **To cite this version:**

Xiao Ma, Modesar Shakoor, Dmytro Vasiukov, Yang Chen, Stepan V Lomov, et al.. Effect of characteristic length parameter in phase-field damage modeling on fibrous composites. 11th European Solid Mechanics Conference, Jul 2022, Galway, Ireland. hal-04301605

HAL Id: hal-04301605

<https://hal.science/hal-04301605>

Submitted on 23 Nov 2023

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Effect of characteristic length parameter in phase-field damage modeling on fibrous composites

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Keywords: Damage modeling, Phase-field, Fast Fourier Transform (FFT).

The phase-field method [1], a modeling technique between fracture and damage mechanics, has gained increased attention in recent years. One of the reasons is that it drops the requirement of other ad-hoc techniques to follow the evolution discontinuities. Indeed, the evolution of the damage variable in the phase-field can fully describe the crack and the damaged regions of material by regularizing the sharp crack as a diffusive damage band.

In the phase-field method, the characteristic length (l_c) that describes the degree of crack diffusion bandwidth is an important parameter and has been widely discussed in the literature. However, people often study it in a homogenous medium. Herein, two types of phase-fields models have been implemented in Fast Fourier Transform (FFT) solver to study their impacts for heterogeneous materials: the first is Miehe's model [1] and the second is Wu's model [5]. In the present investigation, a unit-cell composite model is under transverse tensile loading (Fig. 1(a)), the main goal is to investigate the impact of fiber distance on crack pattern. Figs. 1(b) and (c) show that, for both Miehe's and Wu's models, the damage patterns jump from center to the borders when the l_c becomes too large compared with inter-fiber distance. As for Miehe's model, it is difficult to choose an appropriate l_c to both get proper macro-mechanical responses as well as local-crack patterns. Regarding Wu's model, if the fiber is outside the matrix crack bandwidth, the l_c has no impact both on mechanical response and local crack patterns for whatever the l_c values are.

In summary, in composites materials, when using Wu's model, the l_c value should be as small as possible to avoid the unphysical crack patterns or mechanical responses. In contrast, it is still a challenging topic in Miehe's model.

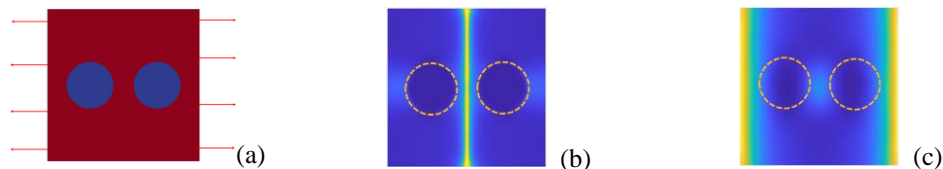


Figure 1. (a) The model with loading direction; (b) The crack pattern of the case l_c is much smaller than inter-fiber distance; (c) The crack pattern of the case l_c is much larger than inter-fiber distance; (orange dash circles are the contours of the fiber).

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