# Effect of fiber packing on POD-based reduced order model for the prediction of elastic properties of continuous fiber-reinforced composite materials

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Multiscale modeling is a powerful approach to understand and predict the mechanical behavior of composite materials. However, this approach still poses notable issues in practice due to large computational loads, especially when numerous simulations are to be performed with varying design parameters [1]. Radermacher et al. [2] have focused on accelerating nonlinear multiscale simulation of fiber-reinforced composites through model order reduction with promising results. However, the approach still demands a significant computational cost that limits its applicability to perform parametric analyses for the design of composite materials and prediction of its mechanical behavior.

In this work, we propose the use of proper orthogonal decomposition (POD) approach for parametric studies of the homogenized elastic properties of fiber-reinforced composite materials. However, one of the critical aspects is the selection of an appropriate set of parameters which need to be varied for the construction of the reduced order model (ROM). Besides an issue of selecting material properties, the location of the fibers which are usually randomly placed in the geometry also raise an issue with respect to the treatment of variable meshes in model order reduction.

To solve the problem of mesh variations, the pre-meshed model shown in Figure 1 (left) is used for the ROM construction. Result from the ROM obtained by varying fiber volume fraction and varying fiber distribution as seen in Figure 1 (middle) is compared with the result from the full order model in Figure 1 (right).

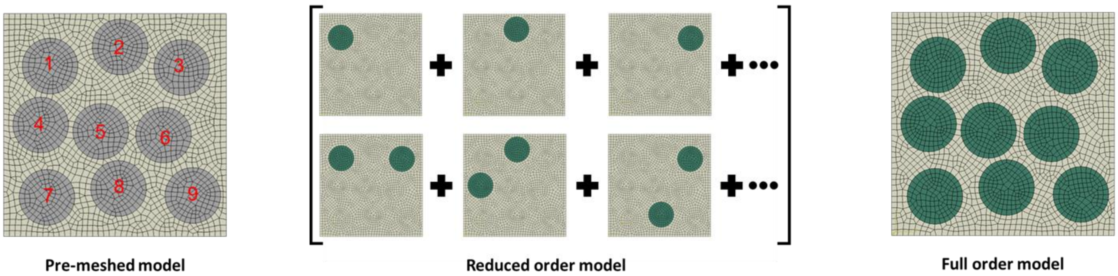


**Figure 1** Pre-meshed model (left), the ROM construction (middle) and the full order model (right)

To assess the applicability of the ROM, this study presents the comparison of effective elastic properties obtained from the full order model, ROM, and analytical homogenization models. More realistic microstructural information can be incorporated in the prediction from ROM comparing to analytical methods with less computational cost than performing full order model simulation.

## REFERENCES

[1] F. Chinesta, A. Leygue, F. Bordeu, J.V. Aguado, E. Cueto, D. Gonzalez, I. Alfaro, A. Ammar, A. Huerta, PGD-based computational vademécum for efficient design, optimization and control. *Arch. Comput. Methods Eng.*, Vol. **20**(1), pp. 31-59, 2013.

[2] A. Radermacher, B.A. Bednarcyk, B. Stier, J. Simon, L. Zhou, S. Reese, Displacement-based multiscale modeling of fiber-reinforced composites by means of proper orthogonal decomposition. *Adv. Model. and Simul. in Eng. Sci.*, pp.3-29, 2016.

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