Alternative error estimate of POD-based reduced order model for the prediction of continuous fibre-reinforced composite responses

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Computational micromechanics is a powerful tool to investigate mechanical behaviour of composite materials. However, it can come with a significant computational cost especially when the system of equations has to be solved repeatedly, for example, in the parametric study. Radermacher et al. [1] have effectively constructed reduced order model (ROM) based on proper orthogonal decomposition (POD) approach to accelerate the simulation of fibre-reinforced composites. However, POD-based approach does not provide any information on the accuracy of the approximated solution obtained from ROM. Error estimators, if they are available, are generally associated with high theoretical cost. A posteriori error estimators were derived for some problems in various research communities [2].

In this work, we employ the POD-based approach for parametric studies of the fibre-reinforced composite materials when considering fibre distribution as the parameter of interest. As an alternative to the error estimator, we propose to monitor the internal force in the interior computational domain and consequently determine the state of the ROM solution. Fluctuations can be seen clearly in the internal force that is obtained from ROM (shown in Figure 1 on the left) as opposed to zero internal force obtained from full order model (FOM). To assess the applicability of the proposed methodology, this study presents the comparison of effective elastic properties and stress distributions obtained from FOM and ROM. Figure 1 (middle and right) shows that ROM can capture the overall stress distribution very well.

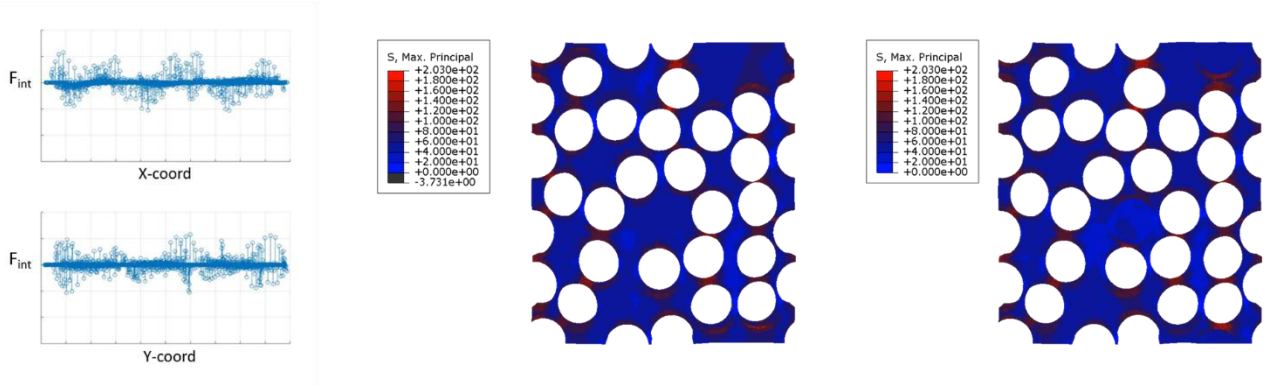

Figure 1 Internal force (F_{int}) in the interior computational domain from ROM (left) and stress distributions under transverse tension from FOM (middle) and ROM (right)

REFERENCES

[1] 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.

[2] P. Benner, S. Gugercin, K. Wilcox, A survey of projection-based model reduction methods for parametric dynamical systems. *SIAM Rev.*, pp. 483-531, 2015.

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