An Investigation of Reduced Order Modelling Techniques in Computational Homogenisation Schemes for Composite Materials

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ABSTRACT

The mechanical behaviour of fibre-reinforced composite materials on the structural level is governed by the behaviour of its various constituents on the microscopic level. It is computationally intractable to model large-scale problems by discretising every single fibre. These costs can be reduced by using computational homogenisation techniques. In these methods, the microscopic behaviour is captured by analysing representative volume elements to obtain the constitutive behaviour of each integration point in the macroscopic model [1]. This approach has been applied successfully to a wide variety of materials, resulting in a significant reduction of the computational effort. This is particularly beneficial for linear problems. Totry et al. demonstrated that computational homogenisation can be used to derive key properties of composite materials [2]. In the case of linear problems, the RVE has to be calculated only once, which yields an enormous reduction of the computational effort. However, when non-linear material behaviour or kinematic relations are present in the micro-model, the solution procedure requires an iterative approach. Hence, the computational costs to compute the microscopic material behaviour are often too high to simulate large-scale problems.

In the literature, the computational homogenisation scheme has recently been extended by applying a reduced order modelling technique to compute the deformation of the representative volume elements [3]. The deformation of the microscopic structure can be reformulated such that deformation modes that are hardly activated can be omitted from the system. The dimensionality of the microscopic problem is thereby reduced. Unfortunately, the efficiency of this approach is still limited, especially for non-linear simulations. Here, the principal directions need to be re-evaluated regularly, which triggers additional computational burden. An extension of the reduced order method is high-performance ROM, where the computational efficiency is increased by reducing the number of interpolation points in the system. In this contribution we investigate the efficiency of ROM techniques for the analysis of the mechanical behaviour of a composite material. To this end we compare the effects of various strategies to update the reduced basis on the computational effort and the numerical error.

REFERENCES

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