The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

A modular nonlinear stochastic finite element formulation for uncertainty estimation in contact mechanics.

Y. Ammouche*[1] and A. Jérusalem[2]

[1] Department of Engineering Science, University of Oxford, Parks Road, Oxford, OX1 3PJ, UK, yanis.ammouche@eng.ox.ac.uk

[2] Department of Engineering Science, University of Oxford, Parks Road, Oxford, OX1 3PJ, UK, antoine.jerusalem@eng.ox.ac.uk

Keywords: *contact mechanics, Galerkin stochastic finite element methods, Cattaneo–Mindlin problem*

The Monte Carlo method has been widely used for the estimation of uncertainties in mechanical engineering design. However, while extremely flexible, this method remains impractical in terms of computational time and scalability. To bypass these limitations, other more efficient approaches such as the Galerkin stochastic finite element method (GSFEM) or the collocation method have been proposed. GSFEM, pioneered by Spanos and Ghanem [1], provides accurate statistics of the output, has the advantage of being sampling-independent and can be modular in terms of operations, albeit code intrusive. While linear elasticity has been extensively covered in the literature, the application of GSFEM to nonlinear mechanical behaviour remains relatively unexplored [2]. Our preliminary work focuses on a seamless and efficient modular framework avoiding the need to know a priori the material law. In particular, we i) make use of a hybrid formulation to capture discontinuous behaviours, illustrated here with a 3D application, and ii) extend the GSFEM to a generic half-plane contact problem where the distribution of shear and normal forces were determined, independently, by Cattaneo and Mindlin [3]. The contact is modelled through boundary conditions, where randomness of parameters, such as friction coefficient, is incorporated in the stochastic formulation. The evolution of output quantities (such as displacement) at the slip-stick transition is then investigated. The results show that the proposed framework is able to capture uncertainties in complex problems such as contact with a fraction of the computing cost of traditional methods.

REFERENCES

[1] Ghanem, R. and Spanos, P.D. *Stochastic Finite Elements: A Spectral Approach.* Springer, Berlin Heidelberg New York, (1991).

[2] Eiermann, M. and Ernst, O. and Ullmann, E. Computational aspects of the stochastic finite element method, *Computing and Visualization in Science*, Vol. **10**, pp. 3–15, (2007).

[3] Mindlin, R.D. Compliance of elastic bodies in contact, *AASME Journal of applied mechanics*, Vol. **16**, pp. 259–268, (1949).

Acknowledgment: The permission of Rolls-Royce to publish this abstract is gratefully acknowledged. This research forms part of the Rolls-Royce led EPSRC Prosperity Partnership ASIMOV EP/S005072/1 entitled "Strategic Partnership in Computational Science for Advanced Simulation and Modelling of Virtual Systems – ASiMoV".