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Variationally consistent homogenisation of shell elements

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Multiscale modelling is frequently used to account for the effects of material heterogeneities on the microlevel. This is achieved via a set of prolongation and homogenisation conditions, which couples the macro and microscale together. This work deals with the multiscale modelling of (thin) structural shells, where the standard continuum assumption of scale separation can not be made. Indeed, the relevant length scale of the microstructure may often be equal to, or even longer than, the thickness of the shell.

Effective methods for homogenising the in-plane membrane and bending effects in structural elements has been shown in e.g Geers et al. [1]. However, accurate capturing of the out-of-plane shear response is not as straigh-forward. This is due to the fact that as the geometrical size of the subscale problem increases, the deformation mode switches from shear to bending when subjected to transverse shear loads, leading to overly compliant out-of-plane shear response. As a remedy to this, Oddy et al. [2] proposed a variationally consistent homogenisation approach with a set of homogenisation conditions for structural planar beam elements. The advantage of their approach is that the macroscopic problem, i.e. the complete beam theory, can be derived from an underlying kinematic description. Furthermore, they demonstrated that this approach is able to capture the correct shear response of the microstructure, even with large length to height ratios.

In this work, we extend the work of Oddy et al. [2] to structural plate and shell elements. We derive a set of prolongation and homogenisation conditions in a kinematically consistent way, and show that a non-standard volumetric constraint emerges when enforcing a deformation-consistent homogenisation procedure. In a series of numerical examples, we show that the membrane, bending, and out-of-plane shear response are accurately homogenised and predicted.

REFERENCES

[1] M.G.D. Geers et al., *Model. Simul. Mater*, Vol. **15**, pp. 393–404, 2007.

[2] C. Oddy et al., On Variationally Consistent Homogenisation for Composite Structural Elements, In Proceedings of the 6th ECCOMAS Thematic Conference on the Mechanical Response of Composites, 2017