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Two-scale computational homogenization of transversely loaded sheets

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Two-scale computational homogenization of transversely loaded sheets

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Introduction

Philips has identified display manufacturing as one of its strategic technologies for the future. Accordingly, there is a strong interest in the research and development of novel displays, including variants of flexible displays. It is important for them to have a procedure for designing fail-safe flexible displays, which can be considered as structured multi-layer shells.

Objective

The objective of this project is to numerically predict the behavior of mechanically loaded thin shell-type structures. For this purpose, a multi-level approach will be pursued via computational homogenization.

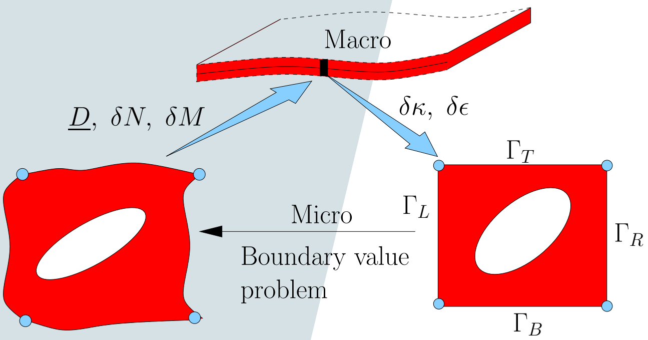

Figure 1 *Computational homogenization scheme.*

Method

Homogenization scheme

A computational homogenization scheme with shell elements at the macro-level and plane-strain elements at the micro-level is used, figure 1. The macroscopic central layer strain ϵ and the curvature κ are used to define the boundary value problem on a representative volume element (RVE). The generalized stress-strain tangent matrix $\underline{D}$ is obtained from an RVE analysis at each macroscopic integration point according to:

$$\underline{D} = \frac{W}{h}\underline{L}^T\underline{K}^*\underline{L} \quad , \qquad \underline{L} = \exp(\epsilon)\begin{bmatrix} 1 & 0 \\ 0 & 0 \\ \kappa & 1 \\ 0 & 0 \end{bmatrix}$$

with W is the RVE width and h the RVE out-of-plane dimension. The reduced stiffness matrix $\underline{K}^*$ is obtained via condensation of the RVE stiffness.

Results

The deformation of a shell with a periodic substructure is studied using both a full-scale model and the proposed multi-level approach. The shell is clamped at the two ends and in the center a vertical load is applied. The material behavior is modeled as elastoplastic with hardening. The results from the full-scale and the multi-scale analysis are shown in figures 2 and 3 (only the left-hand side is shown). The contour plots present the plastic strain.

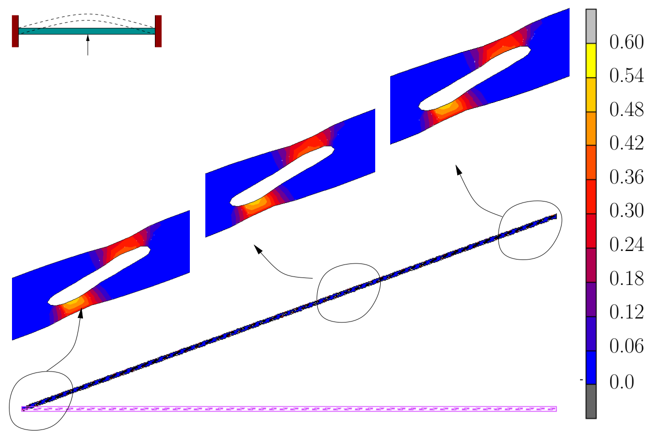

Figure 2 *Results from a full-scale analysis.*

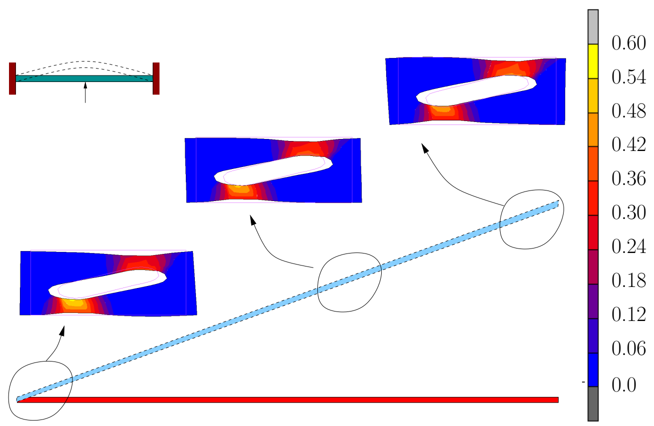

Figure 3 *Results from the multi-scale analysis.*

Discussion

For periodic shell structure the multi-level approach offers a feasible procedure in case a full-scale analysis would be impossible because of excessive calculation time.

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