

# Two-scale computational homogenization of transversely loaded sheets

**Citation for published version (APA):**

Aydemir, A., Brekelmans, W. A. M., & Geers, M. G. D. (2004). *Two-scale computational homogenization of transversely loaded sheets*. Poster session presented at Mate Poster Award 2004 : 9th Annual Poster Contest.

**Document status and date:**

Published: 01/01/2004

**Document Version:**

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

**Please check the document version of this publication:**

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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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.

## 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.

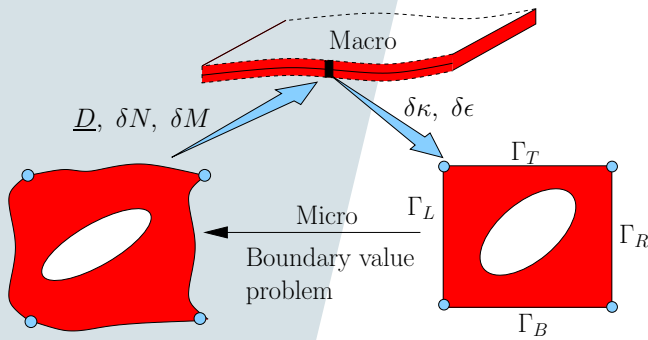


Figure 1 Computational homogenization scheme.

## 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  $\epsilon$  and the curvature  $\kappa$  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:

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

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.

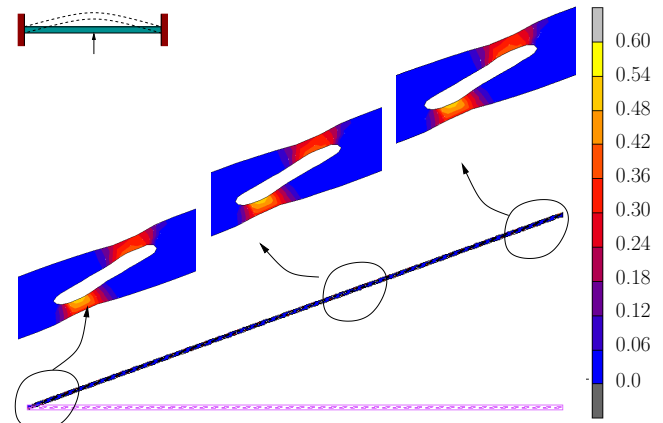


Figure 2 Results from a full-scale analysis.

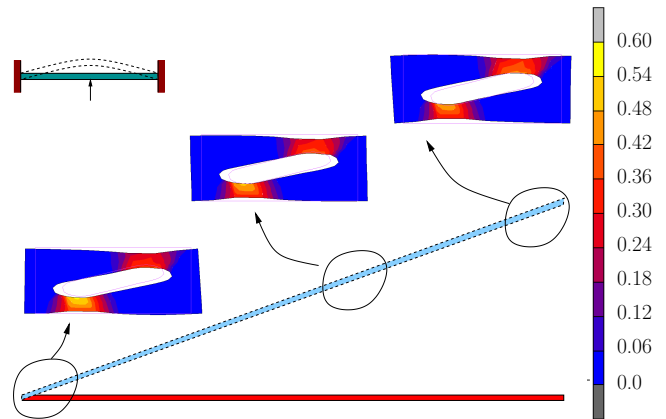


Figure 3 Results from the multi-scale analysis.

## 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.