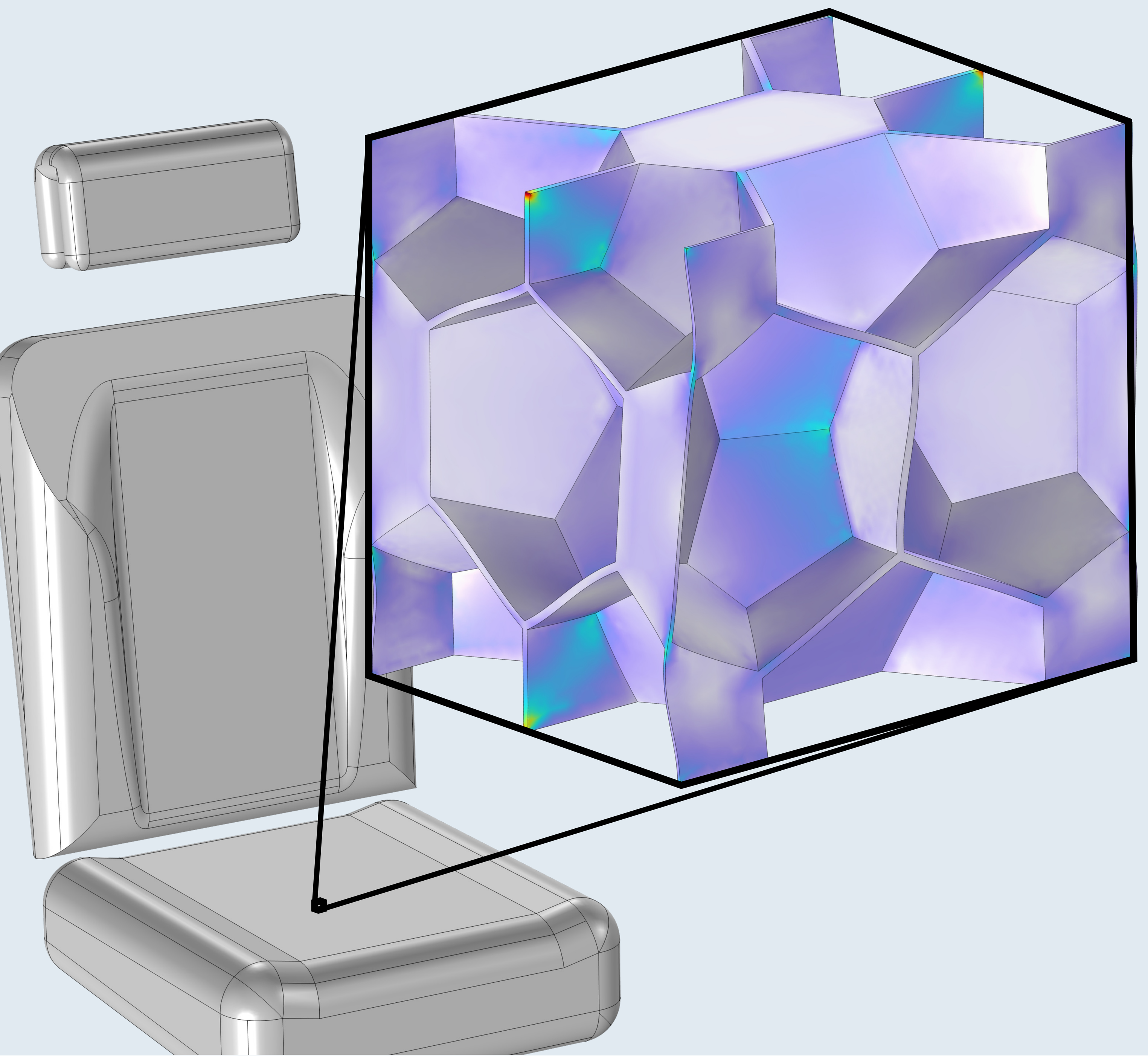

Disruptive Multi-Scale Mechanical Modelling of Micro-Structured Materials: Application to Car Seat Foam

How to predict macroscopic behavior from micro-structured materials?

F. Viry, J.-D. Wheeler, V. Bruyère, P. Namy
SIMTEC, Grenoble, France

Introduction & Goals

The objective of this study is to show the feasibility of microstructure optimization in an engineering application, using periodic homogenization [1].
Periodic homogenization is a technique that is frequently employed by research teams, yet its potential for engineering applications remains largely untapped.
This study proposes a numerical workflow to facilitate the formulation of foams using periodic homogenization. This workflow is exemplified by a case study in which the optimal foam density for a car seat is determined.

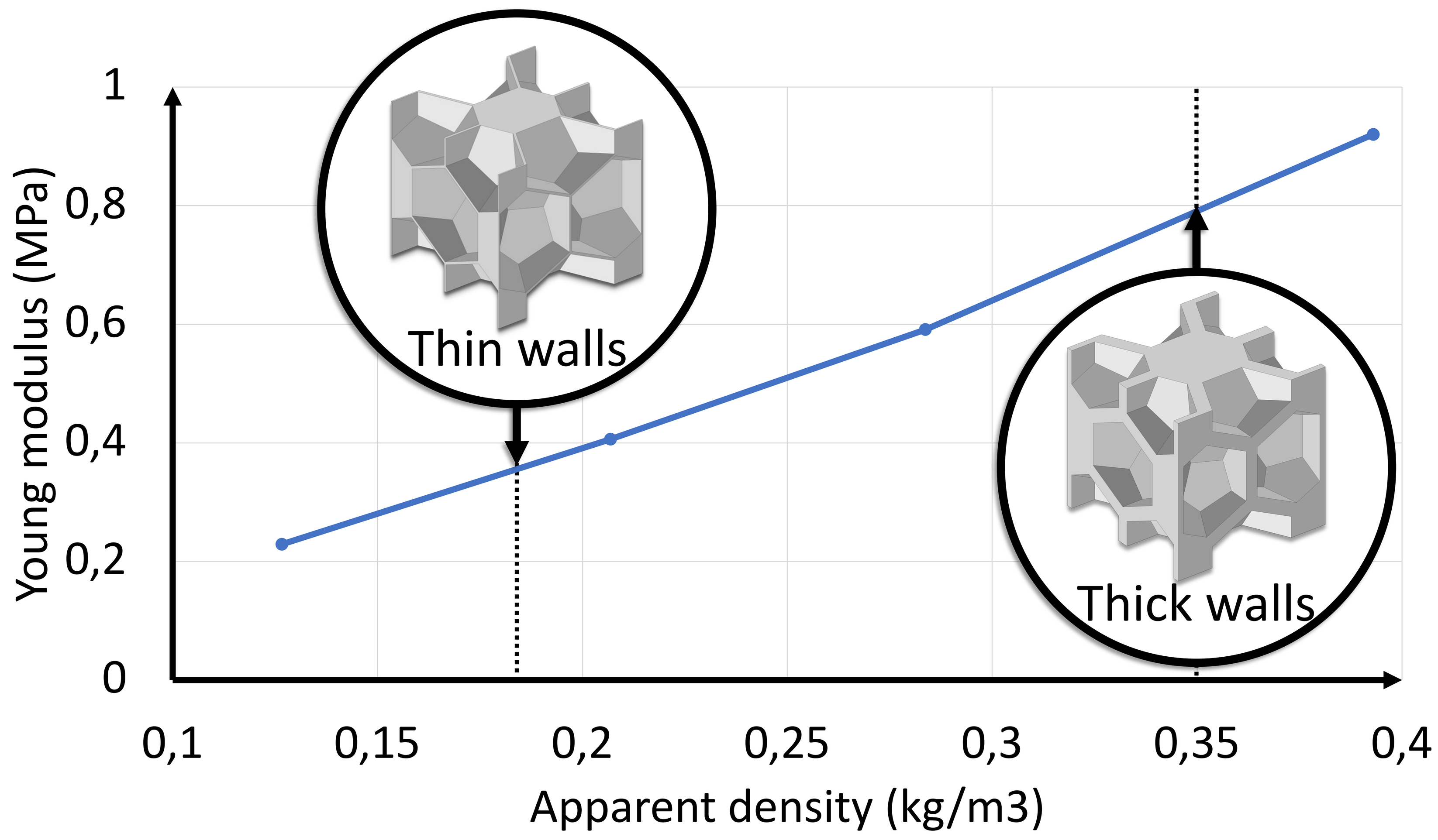

FIGURE 1. Macroscopic properties computed from different foam microstructures.

Step 1: Unit Cell Analysis

Different unit cells are built geometrically, and the **wall thickness** separating the bubbles is varied defining various microstructures. These microstructures show different apparent densities and different Young Modulus (see Figure 1). By computing various unit load cases on each cell, periodic homogenization method establishes precisely the relationship between foam density and foam stiffness (see blue curve in Figure 1). It also clearly outperforms mixing laws [2].

Step 2: Full Car Seat Analysis

In parallel, the car seat is assessed for a given load (in red in Figure 2, left) and fixed constraints (in blue in Figure 2, left). The **Young Modulus** is varied in a large range, and the maximum deformation is recorded for each material case. Then, the ideal Young Modulus is selected based on a max. deformation criterion (Figure 2, right).

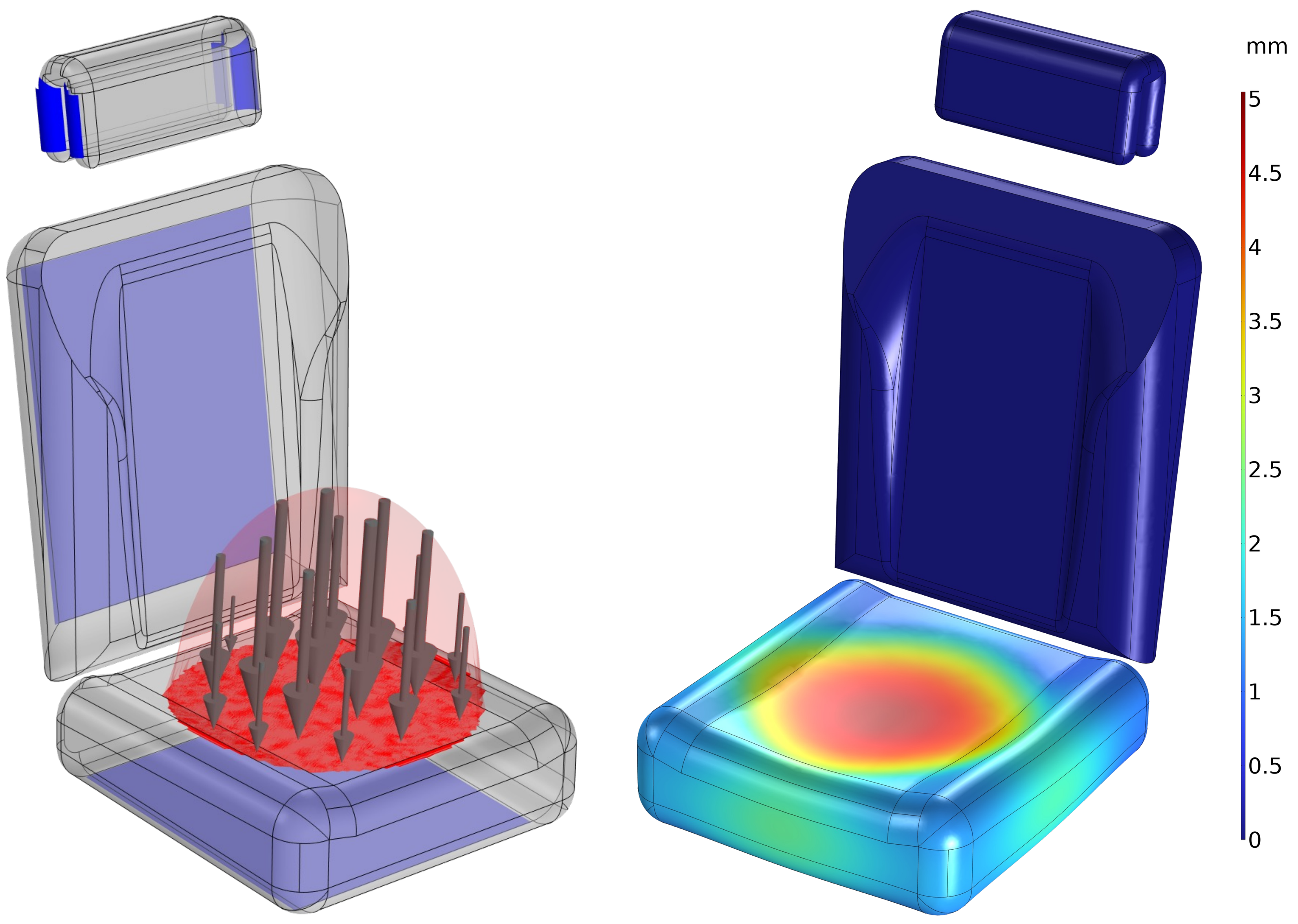

FIGURE 2. Left: Hertzian load applied to the car seat as a reference test. Right: analysis of car seat deformation.

Step 3: Foam Optimization

Finally, thanks to the ideal Young Modulus identified, the optimized foam is selected. Indeed, the unit cell analysis quantitively established the relationship (Figure 1) between foam stiffness and foam density. Thanks to the various direct computations of Step 1 and Step 2, an optimization is achieved in Step 3.

REFERENCES

1. F. Viry, J.-D. Wheeler and P. Namy, "Heat transfers and solid mechanics in microarchitectured materials using periodic homogenization," in COMSOL Conference, Munich, 2023.
2. M. Lévesque, Homogénéisation analytique, Polytechnique Montréal, 2011.