

**EFFECTIVE BEHAVIOR OF ARCHITECTED MATERIALS:
A TESTING MACHINE FOR EXPERIMENTAL HOMOGENIZATION**

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ABSTRACT

With the increasing use of composite materials and the emergence of 3D printing technologies in advanced industrial sectors, the architected materials seem to be one of the main answers to reduce the mass and to increase the performance of structures. As a matter of fact, for such materials, the mesoscopic arrangement of matter gives specific macroscopic properties highly interesting for such structures.

If those materials pave the way for many industrial (r)evolutions, their modeling remains complex, as shown by the numerous references available in the literature. Despite significant improvements in computing power over the last few decades, Direct Numerical Simulations (DNS) of full structural parts at mesoscopic scale are still not conceivable, at least from a design office perspective, and multi-scale models remain currently the modeling tools of choice for architected materials.

However, in most cases, the numerical models used in such simulations are based on CAD drawings whose geometry is known to be perfect. Then, what about the variability of the effective properties, for example, compared to the deviation from the nominal dimensions or from the health materials? Although recent developments have focused on scanning and calculating actual mesostructures ([1]–[3]), these methods can be very expensive both in time and money. In addition, they also require experimental results to validate their overall approach.

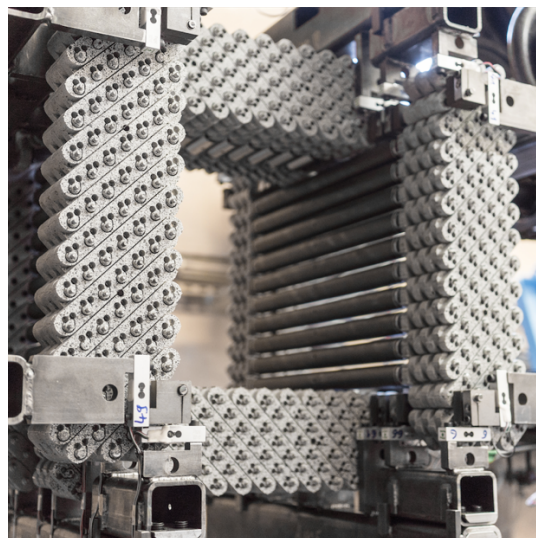


Figure 1: KUBC testing machine.

The purpose of the present work is to develop a device and a method for experimental homogenization (Figure 1). The objective is to avoid the use of digital models by conducting homogenization tests directly on real architected materials, for example from 3D printing. The proposed experimental device, initiated by the work of [4], is based on an arrangement of pantographic structures. It is computer-controlled and allows to impose linear boundary conditions on the boundaries of the sample. It is then possible to perform first-order kinematic homogenization tests (KUBC) on plate structures of size $300 \times 300 \text{ mm}^2$. The pantographic structures also provide access to an estimation of the average stress field on the tested structure. Lastly, the device is clearly adapted to Digital Image Correlation (DIC) devices and allow an extra full-field measurement of the architected material during its loading.

For medium-term perspectives, the device will also make it possible to directly evaluate the invariants of the elasticity tensor. It will then be interesting to evaluate whether it is preferable to construct these invariants experimentally or by post-processing. In addition, some components of the second-order homogenized behaviour are also accessible with this device and perspectives around problems of fatigue or dynamic pre-stressed solicitations could be considered.

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