On the Use of Analytical Homogenization for Modelling of Masonry

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Despite a large number of formulations available in the literature [1], limitations in terms of computational cost, discretization strategy, and calibration effort are still determining factors in the application of numerical models for the analysis of masonry structures.

Brick-to-brick models, where the brick units are used as the basis for the discretization strategy, are associated with heavy computational costs. They are, however, simpler to calibrate than continuous macroscopic models (albeit still difficult), requiring tests to be performed on the interface between brick and mortar and/or on the two constituents themselves.

On the other hand, continuous models at the macro-scale, which treat the material as a homogenous medium, are generally much cheaper to run. However, these models tend to be phenomenological, and therefore very difficult to calibrate: they require multiple destructive tests on large ensembles of bricks, which often cannot be done in practice, particularly when it comes to in-situ assessments of existing structures

Between these two approaches exists a gap in the form of a model which is both possible to calibrate, particularly with limited in-situ testing, and sufficiently cheap to run, potentially applicable to large structures. This is necessary for engineering practice to create full-scale models of existing construction, where masonry is a very typical material for residential and historical buildings as well as infrastructure. An interesting alternative to bridge this gap is the use of homogenization methods.

Homogenization models are based on constitutive formulations at the level of the component materials. Therefore, calibration can often be achieved with small-scale tests, which are suitable for on-site or field-extracted samples. The material behavior is then up-scaled to the macroscopic level, where larger elements can be used for the discretization.

While up-scaling can be done in many different ways, the authors take particular interest in analytical homogenization, as e.g. [2-3]. This approach allows considering phenomena at the constituents' level (brick and mortar), but still limiting computational costs.

The aim of this work is therefore three-fold. First, it contextualizes homogenization-based techniques within the scope of numerical strategies for masonry. While doing so, it also highlights the gap between existing models and material testing limitations, particularly in the case of in-situ and minimally destructive testing. Lastly, it aims at identifying homogenized formulations that can be more easily calibrated and applied to the modeling of existing masonry structures, where the aforementioned limitations play a big role in material characterization.

References

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