A MULTISCALE COMPUTATIONAL STRATEGY WITH TIME-SPACE HOMOGENIZATION

Pierre Ladevèze, Anthony Nouy

LMT-Cachan (ENS Cachan / CNRS / Universit Paris VI)
61 Avenue du President Wilson, F-94235 Cachan CEDEX, France
e-mail: ladeveze@lmt.ens-cachan.fr

When a precise solution is required in the analysis of heterogeneous structures, such as reinforced or composite structures, the calculation must be performed on a fine discretization of the structure (on the micro-level). Since the constituents often have very different mechanical characteristics, the resulting structure is highly heterogeneous and the local solution displays phenomena with a short length of variation. This type of situation leads to problems with very large number of degrees of freedom and the calculation cost is generally prohibitive if one uses classical FE codes. Our objective is to reduce the calculation cost drastically while, at the same time, trying to improve the robustness.

The theory of periodic media homogenization initiated by Sanchez-Palencia [1] is one of the possible strategies to achieve this goal, especially for linear problems. Modified versions have been developed to handle nonlinear problems. However, all these theories are valid only for small ratios between the small scales and the large scales. Moreover, a specific treatment is required at the boundaries, where the material cannot be homogenized.

An answer to this challenge is a new micro-macro computational strategy [3,4] which includes an homogenization technique in both space and time while avoiding the drawbacks of the classical homogenization theory. It is iterative and works over the entire space-time domain. Homogenization is automatically performed along iterations. This approach can be seen also as an alternative to classical homogenization theories. Here, this strategy is detailed for (visco)plastic materials and optional unilateral contact with or without friction.

The first feature of the method consists of partitioning the space-time domain. The structure is an assembly of substructures and interfaces. Each component has its own variables and its own equations. The junction between the ”macro” and the ”micro” scales takes place only at the interfaces. ”Macro” and ”micro” quantities are sort of mean values both over the space and over the time. The resulting structure can be interpreted as a Cosserat-like medium.

The method’s second feature is the use of the so-called LATIN method, a non-incremental iterative computational strategy applied over the entire time interval being studied [2]. At each iteration, one must solve a ”macro” problem, defined on the entire structure and the entire time interval, along with a family of independent linear problems each defined on a composite cell and its boundary. These are ”micro” problems, unlike the ”macro” problem which corresponds to the entire homogenized structure both in time and in space.

Here, after recalling the basic aspects of this multiscale approach, we focus on further works which help once more reduce the computational cost. A first enhancement consists of intoducing a third scale to build an approximation of the ”macro” problem. Another extremely efficient addition concerns the resolution over the space-time domain of the ”micro” problems through a ”radial-type” approximation. Several numerical examples illustrate the possibilities of the approach presented which is designed for composite structure computation.

References

[1] E. Sanchez-Palencia, Comportement local et macroscopique d’un type de mileux physiques heterogenes, *International Journal for Engineering Science*, Vol 12, 231–251, 1974

[2] P. Ladeveze, Nonlinear Computational Structural Mechanics - New Approaches and Non-Incremental Methods of Calculation, *Springer Verlag*, 1999

[3] P. Ladeveze, O. Loiseau, D. Dureisseix, A micro-macro and parallel computational strategy for highly heterogeneous structures, *International Journal for Numerical Methods in Engineering*, Vol 52, 121-138, 2001

[4] P. Ladeveze, A. Nouy, On a Multiscale Computational Strategy with Time and Space Homogenization for Structural Mechanics, *Computer Methods in Applied Mechanics and Engineering,* to appear 2003