11th. World Congress on Computational Mechanics (WCCM XI)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

YIELD DESIGN COMPUTATIONS ON HOMOGENIZED PERIODIC PLATES

Jeremy Bleyer[1,*] **and Patrick de Buhan**[1]

[1] Univeristé Paris-Est, Laboratoire Navier,
Ecole des Ponts ParisTech-IFSTTAR-CNRS (UMR 8205)
6-8 av. Blaise Pascal, Cité Descartes, 77455 Champs-sur-Marne, FRANCE
Email : jeremy.bleyer@enpc.fr, patrick.debuhan@enpc.fr

Key words: *Yield design, Limit analysis, Homogenization theory, Thin plates in bending, Yield surface approximation, Finite element method*

Homogenization approaches have frequently been proposed to evaluate the mechanical properties of highly heterogeneous structures. The determination of such homogenized or macroscopic properties is performed by solving a specific auxiliary problem formulated on an elementary representative volume or a unit cell in the case of periodically heterogeneous materials. Once such properties have been determined, the initial heterogeneous problem is substituted by an equivalent homogeneous one. If global elastic computations using a quite limited number of homogenized moduli are straightforward, this is not the case as regards strength properties. Homogenized yield design or limit analysis computations require, indeed, a semi-analytical description of the homogenized yield surface, simple enough to be efficiently used in an optimization solver.

The following work presents a combined homogenization/approximation approach to perform global computations on periodically heterogeneous thin plates in bending. Homogenization theory in limit analysis or yield design [1, 2] is applied to a thin plate model and macroscopic yield surfaces are derived by solving the auxiliary problem, by means of thin plate finite elements and second-order cone programming.

An original approximation procedure [3] is used to express the so-obtained yield surface as a convex hull of ellipsoids. This simple description enables to formulate yield design problems on a homogenized structure very easily. In particular, a specific attention will be devoted to the formulation of the corresponding static and kinematic approaches as second-order cone programs as well.

An important feature of the method is that upper bound and lower bound status are still preserved on the homogenized problems, so that arising approximation errors can be safely estimated and controlled. Homogenized limit loads can then be bracketed with a relatively good accuracy. Numerical illustrative applications will be presented on various types of structures like reinforced and perforated plates.

REFERENCES

[1] P. Suquet. Elements of homogenization of inelastic solid mechanics, *Homogenization techniques for composite media*, Vol. **272**, 193–278, 1985.

[2] P. de Buhan. A fundamental approach to the yield design of reinforced soil structures, *Ph.D. thesis, Thèse d'Etat*, Paris VI, 1986.

[3] J. Bleyer, P. de Buhan. A greedy algorithm for yield surface approximation, *Comptes Rendus Mécanique*. Vol. **341**, 605–615, 2013.