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MULTI-SCALE COMPUTATIONS DIVERSIFIED: FROM MATERIAL TO DISASTER SCIENCES

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The diversified applicability of homogenization-based multi-scale computations is explored into a variety of physical problems encountered in practice in the broad research areas ranging from material to disaster sciences. Regardless of the kinds of physics, the involved physical phenomenon at global- or macro-scale can mostly be observed as an averaged response of the local- or micro-scale structure with inhomogeneity and complex morphology. Therefore, the characterization of overall mechanical or physical properties of global structures exclusively hinges on the numerical material/structural tests (NMT/NST) conducted on local inhomogeneous structures, whose analysis domains can be referred to as representative elementary domains (RED).

For example, the macro-scale crack growth law is determined by the micro-scale cracking with plastic deformations in crystal grains, which is caused by the change of iron and vacancy concentrations over time, and the growth rate is determined with reference to the results of a series of NST on RED subjected to the macroscopic deformations associated with macroscopic stress intensity factors. Another example is a damage estimation problem in disaster science such that the global (overall) flow properties for tsunami runup simulations in urban or regional areas are characterized by local flow simulations in the RED including structural obstacles such as tide-prevention grove, arranged in a locally periodic manner. We are also concerned with the macroscopic strength of a sea bottom ground underneath sea bottom structures subjected to earthquake motion, which can be affected by the mechanical characteristics of local inhomogeneous structures.

Thus, attention can be directed to multi-scale problems with various spatial scales as follows: (a) investigation of strengthening mechanism of Mg alloys by the crystal-plasticity analyses combined with the thermodynamics model of deformation twinning and the phase-ield model of dynamic re-crystallization, (b) multi-scale crack propagation analysis to assess the residual strength of steel structures subjected to chemical attack, (c) development of a two-scale plate model with in-plane periodic heterogeneity, (d) strength assessment of heterogeneous rock mass with stratified local structure subjected to seismic motion, and (e) study of the effects of locally-periodic structural obstacles on runup characteristics of tsunami, all of which can be performed by either directly applying or extending the method of two-scale analysis with micro-macro decoupling scheme [1].

REFERENCES

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