Department of Civil Engineering and Engineering Mechanics
Columbia University

December 11, Tuesday, 2:30-3:30 pm, in Mudd 327

First estimates of the representative volume element size (RVE) in random elastic composites with residual stresses through nonlocal micromechanics-based models

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Random elastic composites with residual stresses are examined in this seminar with the aim of understanding how the prestress may influence the RVE of the composite. Second gradient approximations of the nonlocal response are considered and the impact of the residual stresses on the estimate of the RVE size is studied whenever the local response is used to describe the mechanical properties of the heterogeneous medium. To this aim, three total and one incremental formulations are undertaken and the influence of both uniform and spatially varying prestresses are studied. Comparison solids characterized by constant elastic moduli could be (i) prestressed under the actual residual stress, (ii) un-prestressed or (iii) subject to an arbitrary residual stress. The corresponding polarizations are introduced to match the stress state of the chosen comparison solids. Like the un-prestressed case treated by Drugan and Willis in 1996, a probabilistic approach is undertaken. A characteristic function is introduced to indicate the presence of a point in a given phase for a given realization of the material. This indicator is used (a) to approximate the moduli, (b) to express the unknown polarization stresses in each phase, (c) to approximate the residual stress and (d) to characterize the displacement in the different phases. A prescribed density allows for defining one point and two points probability functions. The former generates a way to obtain ensemble averages of (a)-(d), where the latter is carried over through the analysis and does appear in Hashin and Strickman effective functionals corresponding to each formulations. Their stationarity, together with averaging the strain field obtained by equilibrium, lead to systems of integral equations for the polarizations in terms of the averaged superimposed strain and of the prestresses in each phase. An incremental approach based on an objective measure of stress is also proposed; the resulting formulation loses self-adjointess and, hence, an alternative functional suitable to extract approximate polarizations must be constructed. Here polarizations depend upon fully averaged quantities, although the drawback is that only homogeneously prestressed media may be treated in this case.

The important issue of estimating the deviation from the second gradient effective response of the local term alone has been raised. In particular, for a fixed deviation from nonlocality, both extensions and shears have been accounted for and estimates of the RVE size in both cases have been achieved. Among other results, it is shown how rapid oscillations of relatively small residual stresses in most cases may result in the impossibility of describing the overall behavior of the composite with a local constitutive equation. On the other hand, prestresses with relatively high amplitudes and slow spatial oscillations may even reduce the RVE size required for approximating the mechanical properties of un-prestressed heterogeneous media with a local constitutive equation.

Biography: Prof. Luca Deseri got his MS in Structural Engineering from the University of Bologna during the celebrations of the "Alma Mater Studiorum Saecularia Nona" and, after almost three years of professional practice as structural engineer, he went back to academia and graduated with his Ph.D. in Theoretical and Applied Mechanics from the University of Pisa, in Italy. He was then post-doc at the Center for Nonlinear Analysis at Carnegie Mellon University and he had his first appointment as assistant professor at the College of Engineering at the University of Ferrara, where he subsequently became associate professor of Solid and Structural Mechanics. While holding this position, he was visiting at the University of Kentucky and he then got his professorship. He was then visiting professor at Cornell University and at Carnegie Mellon, and he was hired as associate dean and professor of Engineering at the University of Molise in Italy, which he left two years later to become professor and department head of the Department of mechanical and Structural Engineering at the University of Trento, ranked n°1 across Italy 12 times in the last 16 years. In the meantime he held more visiting professorships, one at Cornell and one at Carnegie Mellon, where he is currently endowed visiting professor of Mechanics at the Center for Nonlinear Analysis.

Since 2009 he is a member of the directorate of the Italian division of Solid and Structural Mechanics and Coordinator of the Italian Group of Mechanics of Materials, sect. of IUTAM. His main research interests range from the mechanics of structured media with multiple length scales to viscoelasticity and to applications to biology.

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