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Effects of boundary reinforcement on the antiplane shear of linearly elastic materials

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ABSTRACT

The modeling of the mechanical behavior of materials in which the separate mechanics of the bounding surface is known to significantly affect the overall deformation of a bulk solid continues to attract considerable interest in the literature, in particular among researchers in the area of nanomechanics where surface effects are often included in continuum models in an attempt to formulate more accurate descriptions of deformation at the nanoscale. Intuitively, surface effects can be represented by the addition of a prestretched thin elastic film (reinforcing thin film) perfectly bonded to the surface of an elastic body. In this presentation, we consider the antiplane shear of an elastic solid whose boundary is partially coated by such a thin solid film represented here by the union of a finite number of open curves. The end-point conditions to be satisfied at the ends of the film require that we modify the boundary integral equation method by using an equivalent (lower-order) surface condition. This condition is then used to establish rigorous well-posedness/solvability results for the corresponding boundary value problems characterizing the contribution of the film (the surface effect) to the deformation of the bulk solid. We mention also an application of this theory to the analysis of the singularity near an interface crack-tip. We demonstrate that, in the case of antiplane shear, the presence of the film on the crack faces means that the classical square-root singularity is reduced to logarithmic type, whereas in plane-strain deformations the contribution of the film is to effectively eliminate the well-known oscillatory behavior of the displacement and stress fields in the vicinity of the crack-tip leading to a strong square-root stress singularity.