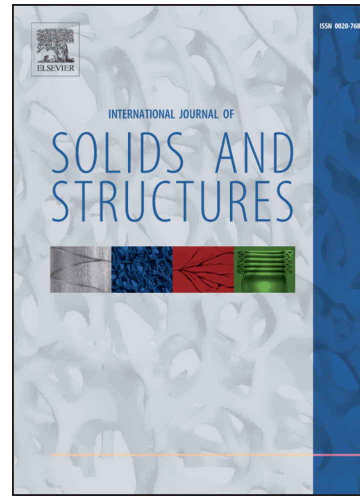

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Dynamic Stability of a Bar Under High Loading Rate: Response to Local Perturbations

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Abstract

Of interest here is the influence of loading rate on the stability of structures where inertia is taken into account. The approach currently used in the literature to analyze these stability problems, is the method of modal analysis that determines the structure's fastest growing wavelength, which is meaningful only for cases where the velocity of the perfect structure is significantly lower than the associated characteristic wave propagation speeds. The novel idea here is to analyze the time-dependent response to perturbations of the transient (high strain rates) states of these structures, in order to understand the initiation of the corresponding failure mechanisms.

We are motivated by the recent experimental studies of Zhang and Ravi-Chandar (2006) on the high strain rate extension of thin rings that show no evidence of a dominant wavelength in their failure mode and no influence of strain-rate sensitivity on the necking strains. In the interest of analytical tractability, we study the extension of an incompressible, nonlinearly elastic bar at different strain rates. The dynamic stability of these bars is studied by following the evolution of localized small perturbations introduced at different times. It is shown that these structures are stable until the static necking strain is reached at some point. Moreover their failure pattern is dictated by the distribution of defects, the minimum distance between necks diminishes with increasing strain rate and there is no dominant wavelength mode, exactly as observed experimentally in Zhang and Ravi-Chandar (2006).

Keywords: Inertia, Energy methods, Nonlinear elasticity

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