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Avalanches and fractals at elastic–plastic–brittle transitions in disordered media

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ABSTRACT

A spring lattice model with the ability to simulate elastic–plastic–brittle transitions in a disordered medium is presented. The model is based on a bilinear constitutive law defined at the spring level and power law-type disorder introduced in the yield and failure limits of the springs. The key parameters of the proposed model effectively control the disorder distribution, significantly affecting the stress–strain response, the damage accumulation process, and the fracture surfaces. The model demonstrates a plastic strain avalanche behavior for perfectly plastic as well as hardening materials with a power-law distribution, in agreement with experiments and related models [1]. The strength of the model is in its generality and ability to interpolate between elastic–plastic hardening and elastic–brittle transitions.

As the next step, we use the spring model to study patterns of plasticity and damage evolution [2]. The set of plastic events and its subset comprised the failure events both are shown to evolve as fractals. The elastic–perfectly plastic transition is observed to follow percolation scaling with (~0.59), implying□ a different universality class (for a finite disorder) than the random = 0.75) due to the presence of long-range po□percolation (wer law correlations. A quantitative analysis of the plastic strain accumulation reveals a bipolar anisotropy (for antiplane loading) which vanishes with increasing hardening modulus. A parametric study with hardening modulus and ductility controlled through the spring level constitutive response demonstrates a wide spectrum of behaviors with varying degree of coupling between plasticity and damage evolution.

REFERENCES

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