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CRITICAL APPRAISAL OF PERIDYNAMICS AND PHASE-FIELD MODELS IN LIGHT OF GAP TEST AND CLASSICAL FRACTURE TESTS

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The recently conceived gap test and its simulation revealed that the fracture energy G_f (or K_c, J_{cr}) of concrete, plastic-hardening metals, composites, and probably most materials can change by ±100% depending on the crack-parallel stresses σ_{xx}, σ_{zz} and their history. Therefore, one must consider not only a finite length but also a finite width of the fracture process zone, along with its tensorial damage behavior. The data from this test, along with ten other classical tests important for fracture problems (nine on concrete, one on sandstone), are optimally fitted to evaluate the performance of the state-of-art phase-field, peridynamic and crack band models. Thanks to its realistic boundary and crack-face conditions as well as its tensorial nature, the crack band model, combined with the microplane damage constitutive law in its latest version-M7, is found to fit all data well. On the contrary, the phase-field models perform poorly. Peridynamic models (both bond-based and state-based) perform even worse, and the recent correction in the bond-associated deformation gradient helps improve the predictions in some experiments, but not all. This confirms the previous strictly theoretical critique (JAM 2016) which showed that peridynamics of all kinds suffers from several conceptual faults: 1) It implies a lattice microstructure; 2) its particle-skipping interactions are a fiction; 4) it ignores shear-resisted particle rotations (which are what lends the lattice discrete particle model (LDPM) its superior performance); 3) its representation of the boundaries, especially the crack and fracture process zone faces, is physically unrealistic; and 5) it cannot reproduce the transitional size effect-a quintessential characteristic of quasibrittleness. The misleading practice of verifying a model with only one or two simple tests matchable by many different models, or showcasing an ad hoc improvement for one type of test while ignoring misfits of others, is pointed out. In closing, the ubiquity of crack-parallel stresses in practical problems of concrete, shale, fiber composites, plastic-hardening metals and materials on submicrometer scale is emphasized.