High Strain-rate Behavior of Cement-based Materials:
A Multiscale Experimental and Modeling Effort

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Blast or impact loads create a far-field compressive loading condition that drives local tensile crack growth from material flaws. Katcoff and Graham-Brady have created a model for high strain-rate compressive loading of brittle materials with circular void flaws following the model of Paliwal and Ramesh (2008) for rectilinear flaws. This two-dimensional, flaw-driven, elastic model is used to predict material strength under constant strain rate loading with local stress intensity dictated by Sammis and Ashby (1986). Here, mortar can be envisioned to contain flaws, such as pores and “slits” (or more linear defects such as interfaces) at various length scales. In order to develop a constitutive model for high-strain rate behavior of cementitious materials, this study presents a multi-scale quantitative characterization mortars with water-to-cement ratios of 0.30, 0.40, and 0.50 with varying entrained air content. The effect of flaws, including macropores (0.05–10 μm), entrained air voids (0.02 to 0.50 mm), and the interfacial transition zone around fine aggregates (0.15 to 0.59 mm nominal size), is considered. Macropore networks are characterized via hydration simulations. Mayercsik and Kurtis have developed a robust probabilistic method to characterize entrained air voids in mortars using data obtained from image analysis. The characteristics of the ITZ are to be studied by hydration simulations and compared with results obtained by nanoindentation. In future efforts, the high-strain rate compressive loading predictions of the micromechanics model will be verified with Kolsky bar tests.