CONCRETE MODELED AS AN INHOMOGENEOUS MATERIAL: NUMERICAL SIMULATIONS[1]

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Applying the power of scalable software, it is now possible to simulate the response of unreinforced- and reinforced-concrete structural elements with zoning or element sizes smaller than the concrete aggregate. Scalable software and hardware allows an analyst to efficiently perform simulations with millions rather than thousands of elements. Using these tools, the fundamental behavior of concrete when subjected to intense transient loadings is being investigated by numerically treating the concrete as a heterogeneous material composed of mortar and aggregate. Modeling concrete at this scale permits much greater latitude to investigate cause and affect relationships. Numerical parameter studies can be used to investigate the effects of varying (1) the strength and compressibility of the mortar and aggregate, (2) the aggregate size, shape, size distribution, and orientation, and (3) the mortar and aggregate bond strength.

The numerical modeling of inhomogeneous concrete requires material characterization of the concrete itself and its two primary constituents, the aggregate and mortar (i.e., the concrete without the large aggregate). In the first stages of this research, high-pressure quasi-static mechanical property tests were conducted on prepared specimens of a 20-MPa concrete, the aggregate material, and the mortar. In the current stage of the research, constitutive models were fit to the recommended properties of the aggregate and mortar. Using finite element meshes that model the large aggregate and the mortar, the response of the simulated concrete under several laboratory imposed boundary conditions, e.g., unconfined compression, triaxial compression, uniaxial strain, and strain-path loading, will be calculated with an explicit parallel finite element code and compared to the laboratory test results.

Acknowledgments

The work described and the resulting data presented herein were obtained from research conducted under the Military Engineering Basic Research Work Package, Work Unit No. AT22-AR-003, "Mortar-Aggregate Interaction in Concrete under Transient Loadings," of the US Army Corps of Engineers by the Engineer Research and Development Center, 3909 Halls Ferry Road, Vicksburg, MS 39180 -6199. Permission was granted by the Chief of Engineers to publish this information.

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