Discrete Modelling of Deterministic Size Effect of Normal-strength and Ultra-high Performance Concrete under Compression

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Abstract:

Size effect of heterogeneous granular materials under tensile loading is well known and the subsequent size effect laws are widely available in the scientific literature. On the contrary, size effect in compression is scarcely studied, which, especially for concrete, is more significant for its brittle failure mode in absence of adequate confinement. This paper investigates the deterministic size effect in compression of two types of concrete: a normal strength concrete and an ultra-high performance concrete (UHPC). The Lattice Discrete Particle Model (LDPM) is selected to determine the compressive strength of a broad range of sizes utilizing experimental-based calibrated data sets. The simulated tests include both cylinders and prisms with the diameter/width range from 150 mm to 600 mm for normal strength concrete and from 50 mm to 200 mm for UHPC. The investigated slenderness ratio ranges from 1 to 16.

It is found that the simulated strength show no size effect under low friction loading, and the magnitude of size effect decreases with rising slenderness ratio under high friction loading. The size effect laws available in the literature are investigated by testing the compressive strength data and found with limitations. A new compressive size effect law formula named CSEL3D is proposed in terms of diameter and slenderness ratio for the deterministic size effect in compression. The correlation by CSEL3D for the studied strengths is above 0.99, which shows its excellent ability in describing and predicting the size effect behavior in compression for both concretes and shapes.