

SISTEMATIC GENERATION OF MESOSCALE CONCRETE MIX-DESIGNS WITH THE DISCRETE ELEMENT METHOD

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ABSTRACT

Mesoscale analysis is a powerful tool for gaining deeper insights into concrete behavior, allowing for a more detailed understanding of stress distribution and the interaction between aggregates and the cementitious matrix. While constitutive modeling is often the most mathematically challenging aspect of the problem, another critical component is the accurate generation of the geometry to be analyzed.

Currently, researchers obtain these geometries either indirectly, using parametric design methods combined with randomization algorithms, or directly through X-ray Computed Tomography (XCT) scanning of concrete samples [1]. Parametric generation with randomization algorithms is generally efficient and effective but lacks physical meaning and imposes limitations on the maximum achievable packing density for complex shapes. Conversely, XCT scanning provides real geometries, but it is constrained by technological limitations on sample size and requires a cumbersome and time-consuming reconstruction process.

The Discrete Element Method (DEM) offers a more realistic alternative for generating these geometries, enabling the use of complex aggregate shapes [2]. In this work, an in-house DEM code—featuring a Vertex-Face/Edge-Edge contact search algorithm, a linear constitutive contact law, and OpenMP parallelization—was used to simulate the pouring of cubic concrete samples. The polyhedral aggregates, obtained from 3D scans, were arranged to conform to a Fuller grading curve. These samples were then analyzed in a Finite Element environment using a proprietary nonlinear elasto-plastic damage constitutive model to evaluate whether their behavior under compressive testing remained consistent across different samples.

The ultimate goal of this project is to provide a simplified yet realistic approach to simulating a wide range of concrete mix designs based only on a granulometry curve. This would enable large-scale comparisons of different concrete formulations, significantly reducing the need for extensive laboratory testing.

REFERENCES

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