INTERPLAY OF SOURCES OF SIZE EFFECTS IN CONCRETE SPECIMENS STUDIED VIA COMPUTATIONAL STOCHASTIC FRACTURE MECHANICS

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We attempt the identification, study and modeling of possible sources of size effects in concrete structures acting both separately and together. We are particularly motivated by the interplay of several identified scaling lengths stemming from the material, boundary conditions and geometry. We model the well published results of direct tensile tests of dog-bone specimens with rotating boundary conditions using methods of stochastic nonlinear fracture mechanics. Firstly, we model the specimens using microplane material law to show that a large portion of the dependence of nominal strength on structural size can be explained deterministically. However, it is clear that more sources of size effect play a part, and we consider two of them. Namely, we model local material strength using an autocorrelated random field attempting to capture a statistical part of the complex size effect, scatter inclusive. Next to it, the strength drop noticeable with small specimens, which was obtained in the experiments is explained by the presence of a weak surface layer of constant thickness (caused e.g. by drying, surface damage, aggregate size limitation at the boundary, or other irregularities). All three named sources (deterministic-energetic, statistical size effects, and the weak layer effect) are believed to be the sources most contributing to the observed strength size effect; the model combining all of them is capable of reproducing the measured data. The computational approach represents a marriage of advanced computational nonlinear fracture mechanics with simulation techniques for random fields representing spatially varying material properties. Using a numerical example, we document how different sources of size effects detrimental to strength can interact and result in relatively complex quasibrittle failure processes. The presented study documents the well known fact that the experimental determination of material parameters (needed for the rational and safe design of structures) is very difficult for quasibrittle materials such as concrete.

Key words: *computational stochastic fracture mechanics, size effect, random field, weak boundary, crack band, microplane model, dog-bone specimens, quasibrittle failure*

1. Introduction

The paper studies the complex size effect on the nominal strength of concrete structures. The target is to identify possible sources of size effect, study them and model them together in one complex model. We want to show how the different sources interact with each other. We are particularly interested in the interaction of different material length scales and the effect of such interaction on size effect.

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