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FE studies on a coupled energetic-statistical size effect in concrete.

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A size effect in concrete elements causes that both the nominal structural strength σ_N and material brittleness decrease with increasing characteristic specimen dimension *D*. Thus, concrete becomes ductile on a small scale and perfectly brittle on a sufficiently large scale. The reasons of this behaviour are [1]: a) the presence of intense strain localization regions with a certain volume which precede macro-cracks and contribute to a deterministic size effect and b) a random distribution of material properties contributing to a statistical size effect. The first statistical theory introduced by Weibull [2] postulates that a structure is as strong as its weakest component. The statistical size effect by Weibull ignores a spatial correlation between local material properties and a deterministic size effect. Combining the energetic theory with a Weibull statistical theory, a general energetic-statistical theory was developed by Bazant [3].

Our extensive numerical FE investigations of a coupled energetic-statistical size effect in unnotched concrete beams of a similar geometry under quasi-static three point bending were performed within elasto-plasticity with non-local softening to obtain mesh-independent results [4], [5]. The FE analyses were carried out with four different beam sizes scaled in two dimensions. Deterministic calculations were performed with the uniform distribution of the tensile strength f_t. In turn, in stochastic calculations, the tensile strength f_t took the form of spatially correlated random fields described by a Gauss distribution (with the prescribed mean value μ_{ft}, standard deviation σ_{ft} and correlation length l_{cor}). In order to reduce the number of stochastic simulations, the stratified sampling technique was applied [4]. In calculations, the length of the spatial correlation l_{cor} ranged from 5 mm up to 150 mm and the material variation coefficient $cov=\sigma_{ft}/\mu_{ft}$ (keeping the constant μ_{ft}) varied between 0.15 and 0.20. Next, FE calculations were carried out assuming simultaneously a cross-correlated spatial distribution [6] of the tensile strength f_t, fracture energy G_f and modulus of elasticity E. The effect of a strong and weak cross-correlation between f_t, G_f and E was investigated.

The numerical outcomes showed a strong coupled energetic-statistical size effect in concrete beams [4]. The influence of the correlation length l_{cor} was found to be strong with reference to the mean nominal strength and its standard deviation. The higher l_{cor} the higher was the coefficient of variation. The increasing material coeficient of variation *cov* coused a reduction of the mean nominal strength. The higher material *cov* the higher was the standard devation of resulting nominl strength. The simultaneously spatially varied parameters f_t, G_f and E did not affect the mean stochastic nominal strength.

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