On the effect of material spatial randomness in lattice simulation of concrete fracture

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Abstract

It has been widely recognized that mechanical properties of materials exhibit a spatial variability. The seminal theory of Weibull (1939) offered simple and powerful tool to determine the probabilistic distribution of structural strength. The advantage of Weibull theory comes from the fact that the mechanics of failure does not interact with the stochastic model. However, applicability of the Weibull theory is limited to brittle structures with no redistribution prior to the peak load.

Many structures are made of quasibrittle materials like concrete, ceramics, rocks or ice. These structures have the ability to partially redistribute released stresses and thus proper mechanics of stress redistribution is needed to estimate their strength. In this study, we adopt the lattice particle-model developed by Cusatis and Cedolin (2007). The Weibull assumption of spatial strength independence stands out against the natural expectation that the local strength fluctuates rather continuously. Spatial material fluctuations are thus introduced by assinging the material properties according to realizations of a random field. According to recent studies by Bažant and Pang (2007), the field distribution have a Gaussian core onto which a power-law tail is grafted.

The model is used for numerical simulations of failure of notched and unnotched three-point bent beams. In the simulations of notched beams, the crack is forced (due to stress singularity) to start at the notch tip. However in unnotched beams, the macrocrack initiates in a locally weaker spot somewhere at the bottom surface of the beam. The effect of material randomness on maximal loads and energy dissipation is studied in both notched and unnotched cases.

References

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