Linking concrete critical length to the mesoscopic structure

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Abstract.

The theory of critical distances is a method that is used to design materials containing defects independently of the severity of the stress concentration [1]. The TCD works by first defining an inherent material strength and a characteristic material length constant, L. Then, the TCD uses these parameters to post-process the linear-elastic stress field near the assessed stress raiser [1]. L is a material property associated with the underneath structural features at micro-, meso, and macro levels [1, 2]. As far as concrete concerns, L is found to be in the order of a few millimeters [3, 4].
This study investigated the possibility of linking L to dimensions of the heterogenic features of un-reinforced concrete. For that purpose, un-notched and notched concrete prisms were manufactured from different concrete mix designs containing different single-sized aggregate particles and a water-to-cement ratio equal to 0.44. The specimens were tested under quasi-static and dynamic 3-point bending. The experimental results showed that L is remarkably constant and independent from both the aggregate particle size or the average spacing among internal aggregates. The cracked surfaces of the notched specimens were visually inspected, especially the regions near the notch tip, which experience the highest tensile stress and the location of the fracture process zone. It is found that L is equal to the average value of the measured vertical distances from the notch tip to the nearest aggregate particles that act as a barrier to arrest the stable cracks propagation. Based on that, the TCD showed predictions within ±20% error scattering. This validation study demonstrates that the proposed answer to the physical essence of L successfully modeled the notched concrete strength subjected to quasi-static/dynamic loadings.

Keywords: The Theory of Critical Distances; Notch; Concrete; Mode I loading.

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