Chapter 1
Introduction to Fracture Mechanics of Concrete

1.1 General

Fracture mechanics is a branch of solid mechanics which deals with the behavior of the material and conditions in the vicinity of a crack and at the crack tip. While the concept of linear elastic fracture mechanics has been well developed for more than past 40 years and successfully applied to metallic structures, several civil engineering materials such as cementitious materials, rocks, and fiber-reinforced composites commonly known as *quasibrittle* need a different fracture mechanics approach to model the fracture process. Cementitious materials can be modeled at various scales like the nano-, micro-, meso-, and macrolevels. At mesolevel, they can be considered as a two-phase particulate composite, i.e., the matrix and the reinforcement. In the cement pastes, mortar, and concrete, the matrices can be considered as the hydrated cement gels, cement paste, and mortar, respectively, whereas the reinforcements in the corresponding materials can be taken as unhydrated cement particles, fine aggregates, and coarse aggregates.

Concrete is made up of many ingredients such as cement, fine aggregates, coarse aggregates, water, and admixtures in complex arrangements. Apart from the two-phase particulate composite, multitudes of internal voids ranging up to several millimeters are present in the hardened concrete (Shah et al. 1995). These voids including pores in cement, cracks at matrix–aggregate interface, and shrinkage cracking have significant influence on the mechanical behavior of concrete. The presence of defects plays an important role and gives rise to a microcracked zone ahead of the tip of a macro-crack, resulting in a progressive material failure as the crack grows. Preceding to unstable or critical load, a sub-critical crack grows when a pre-cracked concrete specimen is loaded. The pre-critical crack growth is often termed as fracture process zone or damage process zone or slow crack growth.

During 1960–1970s, several experimental and numerical investigations proved that the classical form of linear elastic fracture mechanics cannot be applied to normal size concrete members. The inapplicability of linear elastic fracture mechanics was discovered and reasoned as the presence of large and variable size of fracture process zone. From the past research and studies it became clear that the fracture mechanics can be a useful and powerful tool for the analysis of the growth

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