Crack Propagation Mode and Stress Localization in Staggered Biomaterials

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Abstract

Many types of tissue in creatures exhibit well combination of different properties to fulfill mechanical, biological and chemical functions. For example, with more than 90% brittle and hard composites and little protein matrix, nacre and bone has a decent balance between its strength and toughness, which is difficult to achieve in artificial materials. During past years, many researchers focused on the inner mechanisms of these biomaterials for such a high toughness with much brittle component and tried to use these mechanisms to guide the design of biomimetic materials. It is reported that a characteristic rising R-curve is observed in biomaterials, which means their toughness will rise with the crack extension. Many phenomena such as crack bifurcation, mother/daughter crack and crack bridges have been observed using experimental methods. This paper studied the crack extension pattern of the staggered biomaterial using Finite Element Method. The crack initiation and propagation are controlled by cohesive zone model. The simulation result shows apparent two crack propagation modes: localized crack propagation and in-localized one. In localized mode, crack propagates in a small area and the stress and strain concentrates in the crack propagation zone. In in-localized mode, crack initiates in many different points and propagates in various paths. Using the variance based stress localization rate, the two patterns are well described mathematically. The relationship between the material parameters, cohesive zone constitutive relationship, geometric parameters, loading rate and the localization rate is discussed. This study will help clarify the extrinsic toughening mechanism of biomaterials and design the artificial biomimetic materials.