Characteristics and Mechanism of Dynamic Tensile Fracture for Concrete Material under High Strain Rates

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Concrete structures are likely to be subjected to various extreme loads such as earthquakes, impact loads and explosive loads during their service life. When concrete structure suffered from dynamic load, the compressive wave inside the concrete structure will propagate and be reflected on the surface of structure as a tensile wave, resulting in the tensile fracture of the concrete material. This phenomenon is known as spalling of concrete. In the design of concrete structures in construction engineering, bridge engineering and civil air defense engineering, etc., the dynamic tensile properties of concrete materials should be considered, but currently relevant design methods are insufficient. Concrete material exhibits strain-rate effect in nature. With the increasing of strain rate, both the compressive and tensile strength of concrete increase. The crack development process and dynamic failure mechanism of concrete under dynamic tension should be further research. In this paper, the spalling test of concrete was carried out by using a split Hopkinson pressure bar device (SHPB) with a diameter of 100 mm. The spalling process of concrete was analyzed in depth by using a high - speed camera combined with digital image correlation (DIC) technology and validated through simulation. The results show that the development of concrete tensile cracks can be divided into three stages, which are determined by the characteristics of velocity and strain history of the crack in concrete, including the compressive rebound stage, the tensile stage and the failure stage. When the strain rate is around 13s -1, the fracture time decreases with the increase of impact velocity; the initial fracture velocity, the maximum tensile strain and the strain rate are independent of the impact velocity. The K & C constitutive model can well simulate the dynamic strength of concrete, but due to the heterogeneity and internal defects of concrete itself, it cannot accurately predict the location of cracks.

Keywords: Spalling; Dynamic tension; Crack; SHPB; DIC