A Study on the Time-Frequency Characteristics of Electromagnetic Radiation Signals during Concrete Cracking

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Abundant research indicates that, at the moment of rupture, brittle materials such as concrete, coal, and rocks experience a sudden stress change that generates oscillating positive and negative charges on the crack surfaces, resulting in the emission of electromagnetic signals into space. While extensive investigations have focused on the electromagnetic radiation signals produced during the fracturing of coal and rocks, limited attention has been given to the signals arising from concrete cracking. Previous studies have predominantly concentrated on amplitude or frequency domain analysis, lacking a comprehensive exploration of the time-frequency domain characteristics of electromagnetic signals. In this study, various magnetic field sensors capable of collecting frequencies ranging from 50Hz to 50kHz are developed. A laboratory testing platform for concrete cracking is established using data acquisition equipment and a rock point load tester. The electromagnetic radiation signals are subjected to time-frequency domain analysis using Short-Time Fourier Transform (STFT) and Empirical Wavelet Transform (EWT) methods. The study explores the relationship between the time-frequency domain characteristics of electromagnetic radiation signals and concrete dimensions, as well as the instantaneous stress drop at the moment of fracture. Experimental findings reveal that the dominant frequency of electromagnetic radiation signals generated during concrete cracking is in the low-frequency range. As the instantaneous stress drop at the moment of fracture increases, the frequency of the electromagnetic radiation signals shifts towards higher frequencies. Larger concrete dimensions result in greater stress drops at the moment of fracture, leading to higher intensity electromagnetic radiation signals. Utilizing the electromagnetic radiation characteristics of concrete cracking holds promise for monitoring the safety and stability of concrete structures.