Acoustic Emission Entropy: A Realtime Damage-Sensitive Metric for Assessing Bond Deterioration in GFRP-Reinforced Concrete Beams

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An essential goal of acoustic emission (AE) monitoring is the accurate detection of impending critical damage to prevent premature failure by analysing the dynamic evolution of AE parameters. However, a significant limitation of many of these parameters, including count, amplitude, rise time, and others, is their strong dependence on the thresholds and other settings used in the AE data acquisition system. This dependence can distort the original waveform generated by AE sources, posing challenges for precise critical damage identification and early failure prevention. A qualitative AE parameter based on Shannon's entropy, i.e., AE entropy, has been used in the present study to monitor the bond degradation process between glass fiber-reinforced polymer (GFRP) rebars and concrete interface in GFRP-reinforced concrete elements. While AE entropy has been primarily applied to investigate the damage of metallic structures subjected to external loading, the present study explores the applicability of the parameter in the damage assessment due to the bond failure of GFRP-reinforced concrete (GFRP-RC) members. AE entropy is able to depict inherent microstructural alterations and demonstrates superior efficacy in distinguishing between distinct stages of damage and pinpointing crucial damage instances during the bond degradation process, as it is based on the uncertainty surrounding the amplitude distribution of individual AE waveforms and therefore, not affected by the threshold and various time-related parameters. A notable trend in AE entropy has been observed during bond deterioration in the present study. It has been specifically observed that the randomness of events, as quantified by AE entropy, increases in the early stages of bond deterioration but decreases as macro-cracks develop in the later stages. Furthermore, when compared to other parameters like amplitude, AE entropy proves to be more effective in distinguishing between various damage stages and pinpointing critical damage in the bond deterioration process. In summary, the present study demonstrates the utility of AE entropy as a valuable tool for monitoring damage in GFRP-RC structures. Thus, AE entropy can be effectively used for enhancing critical damage identification and preventing premature failures of GFRP-RC structures, as it is not dependent on threshold settings and is able to capture microstructural deformations.