An innovative integrated sensing element (ISE) and its potential application in hydration process monitoring

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Early-age is the most critical stage in the life-cycle of a concrete structure. Any external effects would easily result in permanent damages, lead to performance deterioration, and ultimately affect its service life. Early-age quality control and quality assurance of concrete-based infrastructural systems have become an important issue to realize lifetime health monitoring with rational, real-time, reliable, in-place, and cost-effective techniques. In this research, a novel kind of sensing element integrate a pair of piezoelectric-based sensing elements as transmitter and receiver respectively was designed and fabricated. The feasibility to monitor the quality evaluation of host materials is explored by embedding the ISE into different materials (air, water, fresh and hardened cement paste). Then, the early-age hydration process of cement paste is monitored using an integrated sensing element. The results show that the sensing element can respond well to the performance evolution of the surrounding medium and then realize the in-situ monitoring and characterization of the hydration process. Through frequency domain and wavelet analysis of the coda wave part of the received signal, further accurate characterization of the evolution of the hydration process can be achieved. The coda wave-based frequency domain during the hydration process is analyzed, and its time-dependent process is visualized. And the signal of the characteristic points is obtained, and the corresponding frequency domain and wavelet analysis were further carried out. In the early-age hydration process, a clear frequency shift can be observed. These results show that the proposed method can realize the early-age in-situ hydration process monitoring and its potential to realize the whole-life in-situ health monitoring of concrete-based infrastructure.