Development of Concrete Compressive Strength Monitoring by Non-Contact Ultrasonics

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In this study, a new concept of in-situ concrete strength measurement is proposed. The suggested method simultaneously measures the velocity of longitudinal, shear, and Rayleigh waves by utilizing Snell's Law in air-concrete medium. The multi-particle motions are measured based on the critical angles, and corresponding material properties such as elastic modulus, density and Poisson's ratio can be calculated. To calculate the properties from three different domains, nonlinear regression is applied to obtain the minimal residual of the measurements. In this study, the proposed method was numerically and experimentally validated. In numerical validation, multi-physics simulations were performed to analyze signal variations along the concrete surface in response to varying incident angles of ultrasonic waves. According to the derivation results, the characteristics of the comprehensive concrete were derived through a development algorithm and confirmed numerically. Also, an experimental apparatus was developed to control the incidence angles of ultrasound, enabling to apply the surface of concrete in situ. The study demonstrated that the proposed method enables to estimate concrete material properties and corresponding compressive strength evaluated by additional compressive strength testing. In contrast to conventional approaches, this method provides a distinct advantage in conducting a comprehensive, non-destructive, and non-contact inspection of concrete. This development has great potential to a promising solution for safety monitoring challenges of concrete structures.