Quantitative evaluation of mode I fatigue crack growth using a wireless ultrasonic sensor

Shuo Chen[1], Jin Yeon Kim[2], Guangdong Zhou[3], Yang Wang[2]

[1]College of Civil and Transportation Engineering, Hohai University, China, [1]School of Civil and Environmental Engineering, Georgia Institute of Technology, USA, [1]College of Civil and Transportation Engineering, Hohai University , China

Local fatigue cracks form and propagate in structures subject to dynamic loads, which would ultimately lead to the risk of structural failure. This paper proposes an experimental study aiming to evaluate fatigue crack propagation under mode I through wireless-sensing ultrasonic characteristic parameter. Cyclic tensile loads with a constant amplitude were applied to compact tension specimens to generate mode I fatigue crack propagation. Coupled with fatigue growth test and using self-developed wireless sensing device, ultrasonic measurements were conducted to assess in-situ crack state. According to ASTM standard E647-15e1, the validity of measured data of fatigue crack is verified. Based on crack growth behavior analysis and considering the effect of crack closure, a quantitative relationship between crack length and load cycles were established according to Paris's law and Miner's rule. In addition, through a waveform-based analysis, a tight correspondence between the open-closure status of crack and variation in waveform amplitudes has been discussed. Furthermore, a connection was built between the crack length and the characteristic parameter of the wireless-sensing ultrasonic signal. Using crack length as a link, a mode of I fatigue crack growth model using wireless-sensing ultrasonic signals was established. Through verification, proposed model shows a good agreement with experimental data.