Experimental Characterization of Sulfate Damage of Concrete based on the Harmonic Wave Modulation Technique

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The objective of this paper is to characterize cracking progression of concrete samples subjected to sulfate attack cycles by employment of a nonlinear wave modulation technique. The sidebands in frequency domain \((f_1 \pm f_2)\) are produced due to the modulation of two ultrasonic waves (high frequency \(f_1\) and low frequency \(f_2\)) and the relative amplitude of sidebands is defined as the nonlinear parameter considered as a caliber for structural damage. Different from previous work where the low frequency signal was generated by the instrumented hammer, the low frequency signal in this research is a harmonic wave produced by an electromagnetic exciter to avoid the uncertainty of man-made influence. Experimental results show that the nonlinear parameter presents an excellent correlation with the progress of material deterioration, indicating that the wave modulation method is capable of discriminating different states of damage. Supplementary microscopic analysis and bending tests are conducted to confirm the microcracking development and strength loss during the sulfate attack process. The work validates the feasibility of nonlinear wave modulation technique based on harmonic signals for the damage detection of concrete materials suffered from typical durability problems.

Acknowledgement:
This work is supported by the National Natural Science Foundation of China (Grant No. 51308020) and Beijing Natural Science Foundation (Grant No. 8162027).

Figure 1. Frequency domain signals for damaged sample.  
Figure 2. Frequency domain signals for undamaged sample.

References: