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Time-frequency analysis of electromagnetic wave propagation in rock bolts

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ABSTRACT

Electromagnetic waves have recently been widely used for structural health monitoring of infrastructures due to their ease of sensor installation, simplicity of measurement. The key in structural health monitoring using electromagnetic waves is to capture the waves reflected at defect locations. However, electromagnetic waves reflected from defects often undergo dispersion and attenuation, resulting in waveform distortion that complicates accurate wave interpretation. This study aims to demonstrate the effectiveness of time-frequency analysis in clearly identifying electromagnetic wave reflections caused by defects in rock bolts. In the experimental program, one intact rock bolt and eight defective rock bolts with varying defect lengths were prepared to investigate the influence of defect size on wave propagation characteristics. The measured waves are analyzed in the time-frequency domain using wavelet transform and compared with those analyzed in the time domain. Due to dispersion and attenuation, the reflected waves become distorted, making it difficult to accurately determine the round-trip arrival time. Furthermore, when multiple defects are present, multiple reflected waves are greatly attenuated, complicating the visual identification of reflections. However, the results of the wavelet transform clearly reveal the presence of reflected waves, as indicated by distinct contours that represent the edges of these reflections.

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