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Examination of Single- and Multi-Channel GPR Bridge Deck Condition Assessment Methods with Comparison to Complementary NDE Results

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A sixteen-channel GPR system which houses both longitudinally- and transversely-polarized, 2.0 GHz antenna elements within a single housing was compared with a single-channel GPR system that was separately using both 1.5GHz and 2.6GHz antennas oriented in the transverse polarization, for the purpose of determining effectiveness of bridge deck condition assessment. The multi-channel system has obvious benefits which include closely-spaced GPR antennas (channels) that provide better lateral resolution, as well as combined data sets from co-linear antennas oriented in both the transverse and longitudinal polarizations, which has benefits for imaging within the deck's internal structure. However, the primary objective was to determine whether the multi-channel system would perform in a similar manner to proven single-channel GPR technology during an attenuation-based GPR condition assessment on an older, partially deteriorated deck in northwestern New Jersey that is annually exposed to freeze-thaw conditions as well as de-icing salts. These assessments were made by focusing on identifying the strongest reflections from the upper mat of transversely-oriented rebars within the deck and comparing reflection strength, or conversely, attenuation of the GPR signal, from each of the 'picked' GPR rebar responses. Coordinates for each of the GPR picks, along with amplitude or attenuation measurements, were gridded and contour-plotted for the purpose of identifying areas identified as either relatively deteriorated or sound. Initially, results were compared for data with no applied correction that takes into account GPR signal attenuation with increasing depth within the concrete deck. Final GPR maps were produced incorporating a depth-correction technique similar to what is described by Barnes, et. al., Romero, et. al, and Gucunski, et. al., a process which has been clearly demonstrated to better correlate GPR results with not only ground truth (cores, sounding) but also with other NDE technologies. Not only did all the single- and multi-channel system comparisons generate nearly identical deterioration maps when GPR results were compared and examined, but mapped results obtained from other NDE methods on the same deck were used to identify zones where corrosive environment (electrical resistivity – ER) elastic modulus (ultrasonic surface wave – USW), and identified delaminations (impact-echo – IE) had commonality with the GPR results. A summary of the equipment used, as well as general data collection and analysis procedures is provided for the GPR condition assessments. Brief descriptions of background and references to how the complementary NDT technologies are deployed, and how data are interpreted, are also discussed. Comparative maps for all technologies are used for illustrative purposes.