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GPR measurements and estimation for road subgrade damage caused by neighboring train vibration load

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Generally, road can be simplified as a three-layer structure, including subgrade, subbase and pavement. Subgrade is the native material underneath a constructed road. It is commonly compacted before the road construction, and sometimes stabilized by the addition of asphalt, lime or other modifiers. As the mainly supporting structure, subgrade damage would lead in pavement settlement, displacement and crack. Assessment and monitoring of the subgrade condition currently involves trial pitting and subgrade sampling. However there is a practical limit on spatial density at which trail pits and cores can be taken. Ground penetrating radar (GPR) has been widely used to characterize highway pavement profiling, concrete structure inspection and railroad track ballast estimation. GPR can improve the economics of road maintenance.

Long-term train vibration load might seriously influence the stability of the subgrade of neighboring road. Pavement settlement and obvious cracks have been found at a municipal road cross-under a railway with culvert box method. GPR test was conducted to estimate the subgrade and soil within 2.0 m depth for the further road maintenance. Two survey lines were designed in each lane, and total 12 GPR sections have been implemented. Considering both the penetrating range and the resolution, a antenna with a 500 MHz central frequency was chosen for on-site GPR data collection. For data acquisition, we used the default operating environment and scanning parameters for the RAMAC system: 60kHz transmission rate, 50 ns time window, 1024 samples per scan and 0.1 m step-size. Continuous operation was used; the antenna was placed on the road surface and slowly moved along the road.

The strong surrounding disturbance related to railroad and attachments, might decrease the reliability of interpretation results. Some routine process methods (including the background removing, filtering) have been applied to suppress the background noise. Additionally, attribute analysis is an important tool that focused on the multi-properties of the signal. Here, cross-correlation attribute analysis has been applied for GPR profile interpretation. It compares one trace with surrounding traces to determine degrees of similar, and improves the difference between the reflected wave from detection target and its surrounding mediums, which makes it easy to detect the anomaly that couldn't be found in original GPR time profile. It's possible to identify sections of subgrade in good or worse condition, which may require specific maintenance or trail pitting investigation.