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GPR measurements for the distribution of thixotropic slurry behind segments in large diameter and long distance pipe-jacking construction

Yonghui Zhao (1), Jiansheng Wu (1), Xiongyao Xie (2), and Chenchao Zeng (2)

(1) Tongji University, School of Ocean & Earth Sciences, Shanghai, China (zhaoyh@tongji.edu.cn), (2) Tongji University, Department of Geotechnical Engineering, Shanghai, China

It is very important to form an integrated ring of thixotropic slurry around the pipe segments to reduce resistance during large diameter and long distance pipe jacking. Furthermore, the integrated slurry ring between the pipe and the excavated soil can effectively reduce the soil disturbance caused by the pipes, and minimize ground settlement. It is necessary to real-time monitor the spatial distribution of the thixotripic slurry during jacking process. The traditional solution to estimate the outlines of slurry ring is the jacking load and the injecting pressure. If the jacking load increases, which means more slurry should be injected to reduce the jacking load. However, this solution couldn't provide the distribution of the slurry beneath pipe segments, and locate the zones which need to be injected enough slurry.

Ground penetrating radar (GPR) has been successfully used to detect the thickness of the grouting behind the shield tunnel segments in last several years. An important factor is the dielectric difference between grouting and soil. Similarly, the interface between the liquid slurry with high relative electric permittivity and surrounding soil, should be recognized from GPR image due to the distinct dielectric difference. Here, GPR experiment has been conducted on a sewage pipe jacking engineering. The purpose of the survey is to evaluate the distribution of the thixotropic slurry through GPR image. In this sewage jacking engineering, the width and the thickness of each pipe segments is 200 cm and 30 cm, respectively. Considering the resolution and propagation range of radar wave, ground coupled bowtie antenna of 900 MHz frequency has been selected for GPR data acquisition. A series of circular GPR data have been collected along the inner surface of pipe segments. In addition, sampling of slurry has been performed on four different segments. The relative electric permittivity and conductivity of the thixotropic slurry have been measured by using time domain reflectometer (TDR). The velocity of propagation in slurry is calculated by dielectric characteristics, which extremely improves the resolution of time-depth conversion.

Some process methods, including moving average, AGC and migration, have been applied to improve the quality of each GPR images. It's possible to recognize the reflection wave from the slurry-soil interface from the processed images. Combined the exact velocity estimation, the two-way travel time between pipe-slurry and slurry-soil interfaces can be converted to the thickness of the slurry ring. The experiment results show that GPR is able to evaluate the distribution of the liquid thixotropic slurry behind pipe segments in large diameter and long distance jacking. The velocity measured by TDR can significantly reduce the error caused by the time-depth conversion.