Submission code: RXKYG9AJXY

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Ground Penetrating Radar (GPR) for Urban Subsurface Investigations Case Studies from São Paulo

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Ground Penetrating Radar (GPR) for Urban Subsurface Investigations: Case Studies from São Paulo

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Introduction

This paper presents six case studies involving pavement evaluation, structural inspection, foundation detection, and tunnel lining assessment carried out in São Paulo. These studies highlight the operational efficiency and technical capabilities of Ground Penetrating Radar (GPR) in complex urban environments. The results demonstrate how GPR contributes to decision-making processes in infrastructure diagnostics, maintenance, and engineering interventions, particularly in scenarios where non-invasive subsurface characterization is required.

Method

Ground Penetrating Radar (GPR) is a non-invasive geophysical method widely employed for high-resolution subsurface investigations in urban settings. The technique operates by transmitting high-frequency electromagnetic pulses into the ground and analyzing the reflected signals generated by contrasts in dielectric permittivity between subsurface materials. Interfaces with high dielectric contrast — such as concrete-to-steel boundaries — produce strong reflections. Conversely, materials with high electrical conductivity, such as saturated clays, attenuate the radar signal and limit its penetration depth.

For the case studies presented, a shielded 1.6 GHz antenna was employed, optimized for detailed shallow investigations, with typical penetration depths ranging from 0.3 to 0.5 meters in low-loss materials like concrete. The data acquisition process followed standardized procedures, including background removal, gain correction, migration, and time-to-depth conversion based on estimated electromagnetic wave velocities appropriate to each site condition.

Results and Conclusions

The six case studies demonstrated the versatility and reliability of GPR for urban subsurface investigations. In a controlled laboratory environment, the method successfully detected voids and embedded objects within a concrete test block. Pavement surveys revealed stratigraphic layers and identified anomalies such as voids and moisture ingress. Bridge deck inspections enabled the identification of asphalt thickness, concrete slabs, reinforcement bars, and potential voids. GPR also proved effective in mapping reinforcement in columns, beams, and slabs, as well as detecting foundation elements in built environments, including warehouses and residential buildings. In tunnel assessments, the concrete lining thickness was measured with high accuracy, showing a strong correlation with construction records.

Despite limitations in highly conductive soils, the results confirm that GPR is a practical and efficient tool for non-destructive diagnostics, offering rapid deployment and reliable data to support infrastructure assessment and maintenance in complex urban settings.