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Three-dimensional analysis of a developing sinkhole using GPR and dynamic cone penetrometer (DCP) testing

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Ground penetrating radar (GPR) imaging is one of the most promising non-destructive and non-invasive methods that have offered new opportunities for mapping shallow subsurface disturbances in urbanized and industrialized zones. However, difficulties often arise in choosing the optimum antenna frequency to image subsurface features. While high frequency antennas may provide lots of detail, lower frequency antennas may provide information on larger-scale features that provide more site context. In this study, we performed GPR surveys to investigate a zone of subtle surface subsidence and pavement cracking on reclaimed land at a quayside. A 3-stage approach was used, and included: (1) a 250 MHz antenna survey to delineate the spatial extent of the area of interest; (2) a 500 MHz antenna survey to yield greater detail; and (3) direct verification of some of the key features using dynamic cone penetrometer (DCP) testing to "ground-truth" anomalies. This staged approach proved successful in imaging the sub-grade, and minor voids within approximately 2 m depth. Moreover, the quality of the data can be further improved by using GPR-Slice software in conjunction with DCP data to develop a 3D ground model. Through this approach, a combination of GPR survey and direct testing, we demonstrate the efficiency and quality of this method in mapping shallow subsidence features. An interpretation of the process-origin of the collapse feature is also proposed.