A case study of 3-D GPR survey and the ground truth at test sites for detection of buried objects

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Various lifelines such as water and sewage, electricity, gas, telecommunications, etc. are located in the shallow underground of urban areas, but due to inaccurate information in that area, there are many accidents cutting buried objects during excavation. Therefore, in order to prevent those accidents , it is essential to acquire more accurate locations and construct a 3-D model of the underground. Geophysical techniques are effective methods for modeling the buried objects. We constructed a test facility to develop and evaluate the method reconstructing the 3-D model of the buried objects. In this presentation, we introduce the outline of the constructed facility and report a case study of 3-D GPR (Ground Penetrating Radar).
The test facility's road is approximately 408 meters in total length and 5 meters wide, designed to drive with the speed up to 60 km/h, and divided into three main sites where objects were buried. At Site 1, various buried objects supposed under the ground of urban areas were installed (Fig. 1 a). These include the buried objects such as manholes, sewer pipes, gas pipes, flexible electrical conduits, void models, steel sheet piles, concrete blocks, wooden piles, dummy unexploded ordnances, and bricks. At Site 2, void models and VP pipes (uPVC; unplasticized polyvinyl chloride pipes) were installed (Fig. 1 b). The 28 void models which were made of Styrofoam and composed of four sizes were buried under from just below the pavement to the maximum depth of 3.5 m. The 4 VP pipes with different inner diameters were laid, and had the structure which enable us to inject and drain water. At Site 3, Hume concrete pipes were installed (Fig. 1 c). The Hume pipes with two different inner diameters were used and arrayed various patterns. The maximum depth of the bottom is 2.7 m.
We used a terrestrial laser scanner to obtain point clouds data that captured the exact position and shape of the buried objects before soil covering so as to realize 3-D comparison between the survey results and the actual burial situation. For the construction records, 3-D models were created by aerially photographing the buried object using a UAV and a rod of 6m for camera. Furthermore, considering seasonal fluctuations in soil condition, we have been so far observed not only rainfall on the ground but soil moistures, temperatures, and electrical conductivities of six different depths at a monitoring point.
We conducted highly dense GPR survey for the Site 1 and the Site 3. The survey lines were spaced at intervals of about 25 cm in the longitudinal and transversal directions of the road. Assuming that the hyperbolic curve to the data obtained by surveying the buried pipes is a travel time curve from a point reflection, we can calculate the propagation velocity so that maximized the semblance along the curve. As the results of visualizing the spatial distribution of the semblance, the characteristic feature of the buried pipes could be visualized.
Now, the Ministry of Land, Infrastructure, Transport and Tourism Japan has promoted BIM/CIM to improve the productivity by integrally sharing and utilizing 3-D models with related parties throughout the processes of design, construction and maintenance. In that trend, 3-D modeling of buried objects is in the midst of a validation.
We aim to accelerate the open innovation of 3-D survey technology and diffuse it as an effective use for BIM/CIM by sharing and utilizing this facility with other research institutions and companies in the future.

Keywords: GPR, buried objects, test sites, 3D model

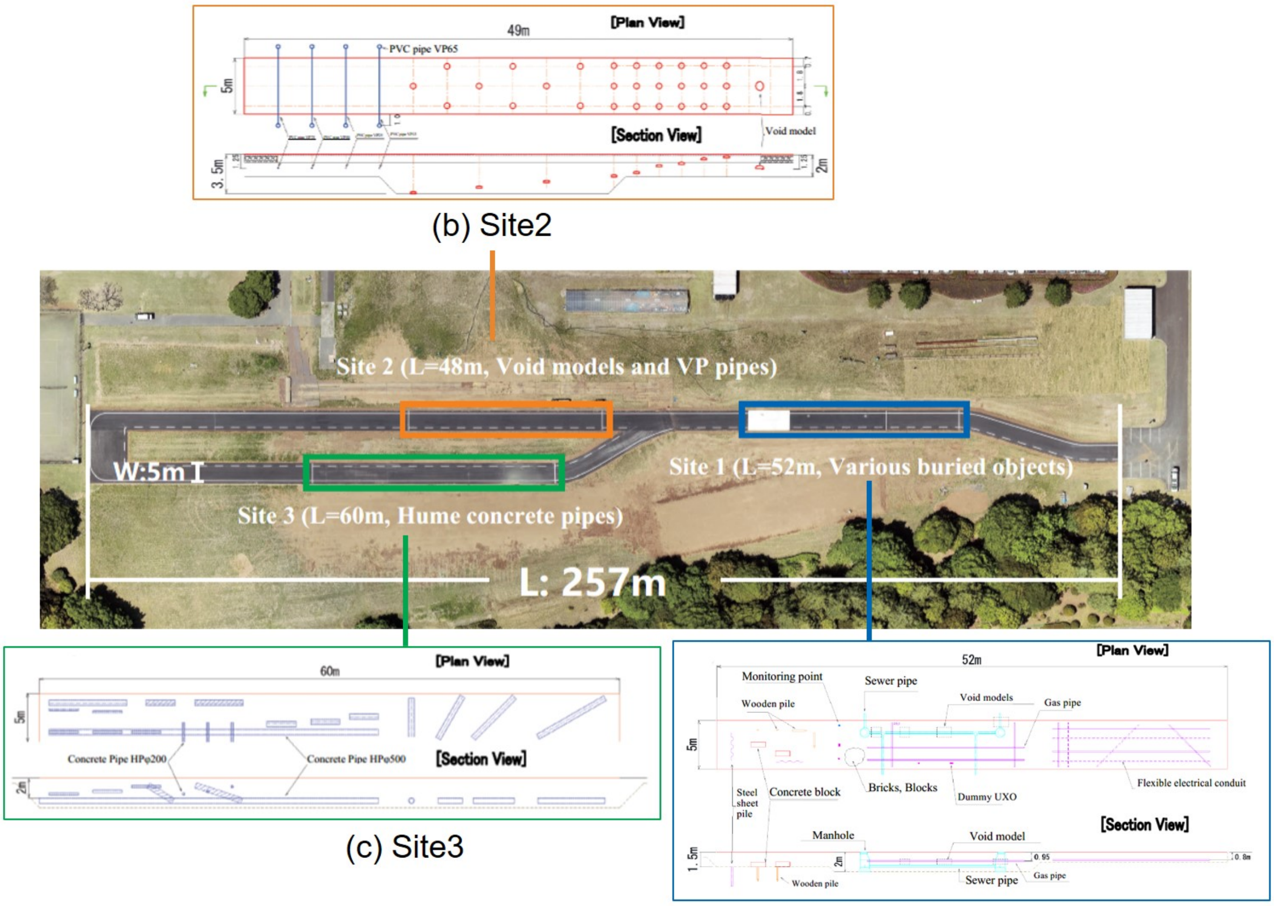

Fig. 1 View of the test facility

(a) Site1