A CASE STUDY OF GROUND-PENETRATING RADAR APPLIED AT CUTTING POSITION OF UNDERGROUND PIPING

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ABSTRACT

The application of GPR (Ground-Penetrating Radar) under NDT (Non-Destructive Testing) is very extensive. Many research literatures have indicated the importance of pipe detecting and the value of its application. Before excavation for maintenance of underground piping, it is necessary to understand the various site problems on topography and surface materials (e.g. position (depth and displacement) and size of other piping, as well as manholes); otherwise, severe damage will be generated from mistaken excavation of other piping. The severity might even affect the corporate image and living resources such as electricity, telecommunication and hydrology. This study uses GPR under NDT as a tool to discuss the cutting position of underground pipeline through a practical on-site example. After an actual detect on three sections using ground-penetrating radar, this study verified that there is one underground pipe cut off in the region. The pipeline is approximately 10 cm in diameter at a depth of about 0.9 m from ground surface. With such a result, it can be concluded that GPR is an effective detecting tool and as such can be used for future reference in research and work requirements.

Key Words: GPR(Ground-Penetrating Radar), NDT(Non-Destructive Testing),Underground piping.

INTRODUCTION

The As Taiwan has an extensive amount of underground piping, difficulties and risks often arise in the commencement of underground excavation work when the correct position of buried piping has not been confirmed. The conventional method of open excavation is not economical and it impacts negatively on traffic. Furthermore, mistaken excavation or damage to other piping generates unnecessary cost and inconvenience to the public. In view of this, if the NDT-GPR capable of fast detection can be used and incorporated with relevant data for further determination, the distribution status of underground piping can be controlled more precisely and cost estimates can be surely reduced.

This article applied the GPR advantages of fast testing, high resolution and NDT for case discussion on the position of cut underground piping. After excavation, the existence of a cut piping was verified in the target area.

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Principles of GPR

The GPR applies the principle of wave reflection that generates 10MHz to 2Gz of wave (radar wave) for duration of nano-second (ns) via a power discharge coil of several volts. The wave is penetrated into underground or building structures and is reflected to the ground surface via an underground stratum interface of a different electromagnetism. There a highly sensitive antenna receives partial signals and automatically stores them. The recording time is determined according to the detection of the target for a minimum of 1 ns and a maximum of 32767 ns. After general processes such as compensation for declined amplitude and filter plus special processes including Velocity analysis, Deconvolution and Migration, the data recorded generates a double wave section and this is used to plot the profile of the underground stratum and detection of artificial objects buried underground.
Figure 1 is the "Illustration of GPR survey"; among it, Tx represents the transmission antenna and Rx the receiver antenna. While moving along ground surface, the GPR transmits a wave to penetrate the stratum to reach the interface below ground surface. The reflected wave generated is picked up by reception antenna when it returns to ground surface, which produces the following image and shape of the interface.
The SIR-3000 machine (Figure 2) and 400MHz antenna (Figure 3) were used as the GPR equipment in the case.

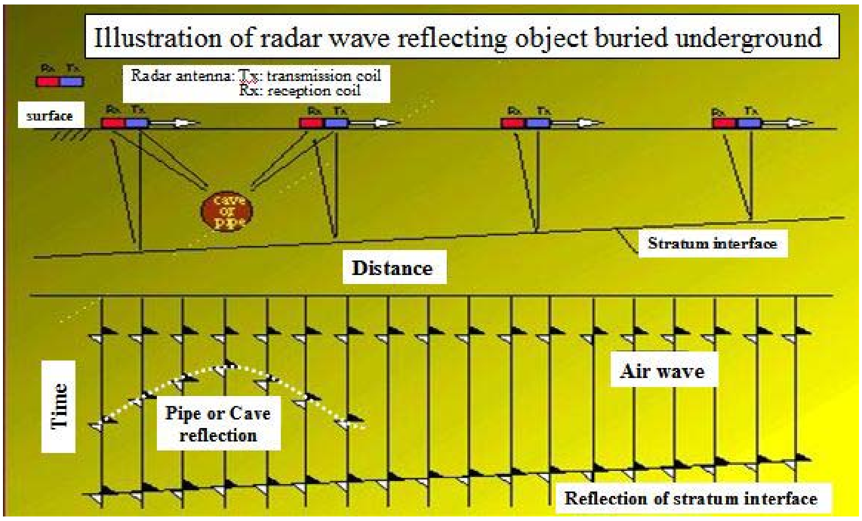

Figure 1. Illustration of GPR survey

Figure 2. GSSI SIR-3000 machine

Figure 3. 400MHz antenna

Literature Review

The application of GPR in the engineering industry has been very extensive. Many expert studies and scholarly discussions exist on detects of underground piping. Results of early researches made by Kovas (1991) [1] and Mellet (1992) [2], were positive in allocating the location of underground piping with GPR. Tong (1993) [3] used GPR to detect piping buried underground and the result indicated that the piping would generate a reflection image of an inverted “V” under the GPR scan and the underground cable would also generate a diffraction of a similar shape. Zeng and Mcmechan (1997) [4] used the GPR characteristics for value simulation and migration analysis of piping. The result was able to indicate the size of the pipe’s diameter. Lo (1998) [5] applied GPR for a study of piping and stratum investigation and significant effects were obtained from the results. Chuang (2000) [6] applied the step geology radar in both simulation and site testing to detect objects buried underground. The ability of geology radar for piping detection was excellent, but since the effect of detection was influenced significantly by attenuation, piping material and size of pipe diameter, detection and interpretation would be difficult if the geological status on site was not known. Hsu (2003) [7] used GPR to detect the correct location of underground piping and performed simulated tests according to the principle. From there, a set of correct concepts and principles of determination for GPR application was established. Over recent years, it has been very popular to apply GPR for detecting the location and material of underground piping. Wang (2006) [8] combined GPR with an artificial neural network to identify type of underground piping. The objective of such a study was to establish the mechanism for determining an artificial neural network, so that the radar signal of underground piping could be identified effectively. Results obtained from the study by Chang (2007) [9] indicated that by using the high resolution characteristic of high frequency GPR with testing and analysis to understand the radar wave, the analysis and determination for objects to be tested could be controlled further after improvement. Wu and Chang (2007) [10] used GPR to test the status of road base. The radar test sections after data processing via reflection of GPR wave were compared, discussed and analyzed, and research results were expected to assist with the interpretation of underground piping.

Data Collection

The site was located on Zhongzheng West Road, Zhubei City, Hsinchu County (Figure 4). At specified sections of road construction, the position of old cut pipe was detected in order to understand its original location, to prevent mistaken pipe excavation, and to lay new pipe. As shown in Figures 5 and 6, the position and orientation of underground piping for the area was estimated first. After setting out three lines using the GPR method, the correct header position for the cut pipe could be interpreted via the reflection signal of the radar wave.

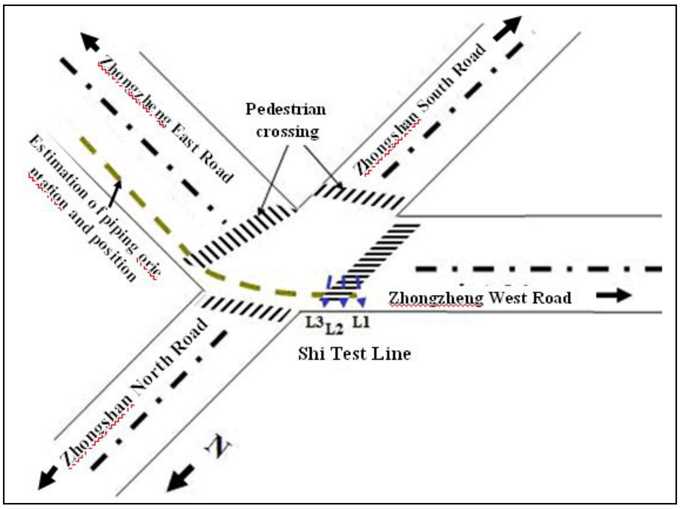

Figure 4. Illustration of GPR Lines

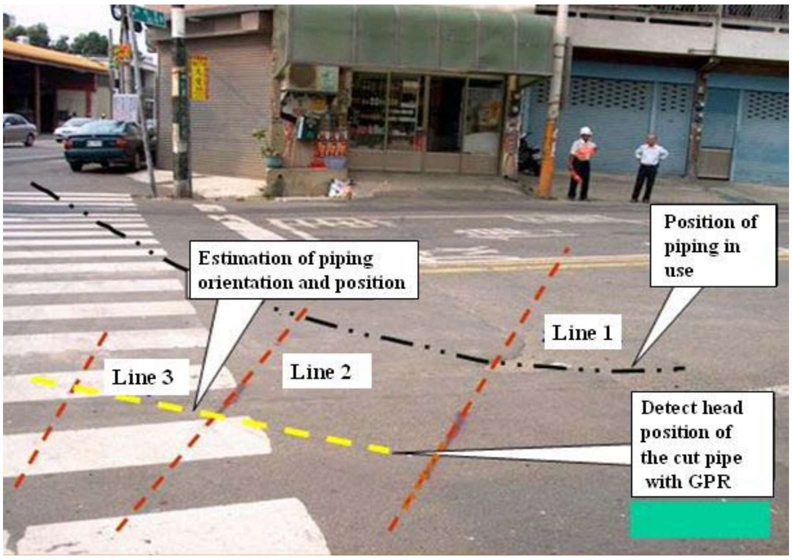

Figure 5. Detecting position on site

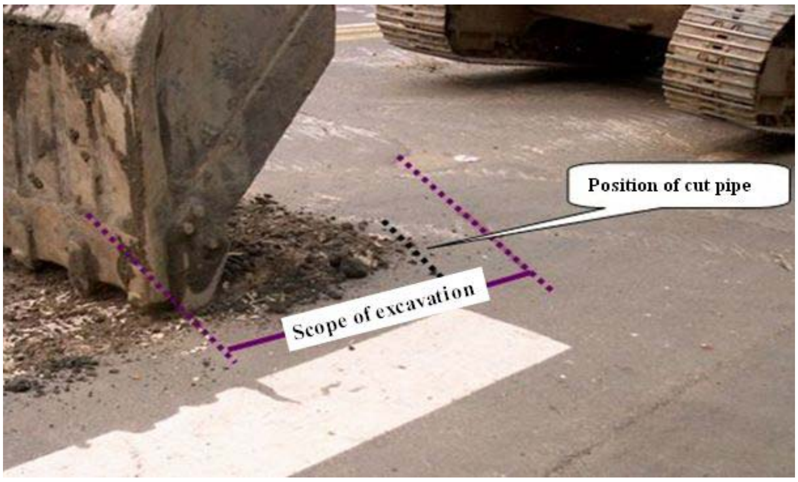

Figure 6. Excavation on site

Analysis and Interpretation

After executing necessary data processing (Filter, Gain, Migration, Deconvolution…) of original section first, the results could be observed from the sections:

(1) First Line

The piping was not visible from the GPR section (Figure 7), which indicated that the piping did not pass the spot tested.

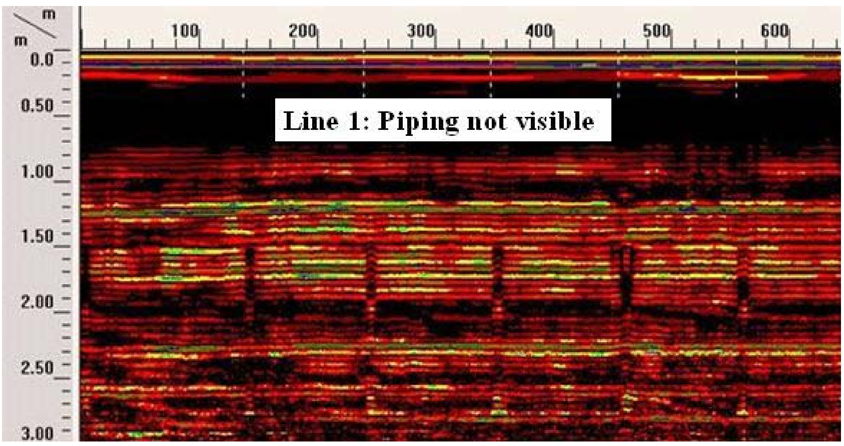

Figure 7. Section of GPR Line 1

(2) Second Line

From the GPR test section, disturbance was found underground approximately 1m away from the displacement and piping existed at a depth of approximately 0.9m (Figure 8), which indicated that the piping did pass the spot tested.

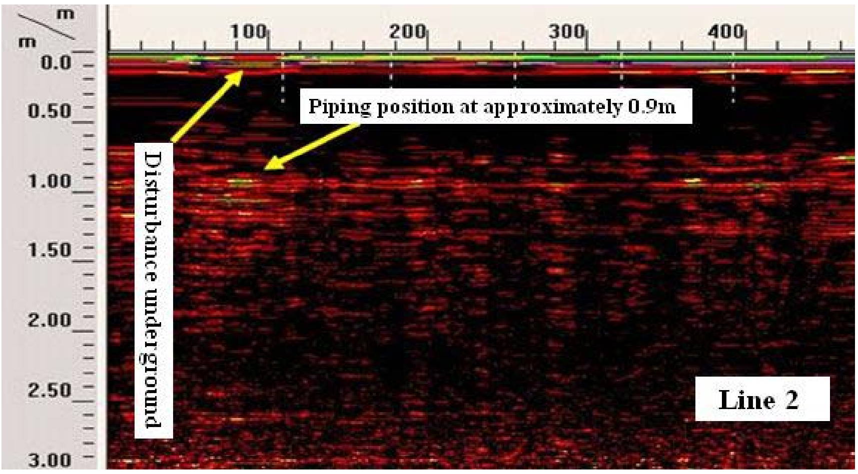

Figure 8. Section of GPR Line 2

(3) Third Line

From the GPR test section, disturbance was found underground approximately 5.5m away from the displacement and piping existed at a depth of approximately 0.9m (Figure 9), which indicated that the piping did pass the spot tested.

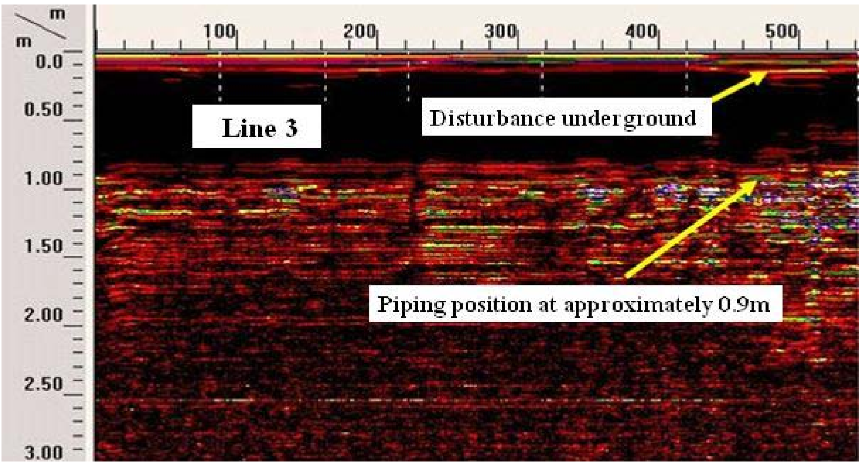

Figure 9. Section of GPR Line 3

(4) By excavating according to the result of reading the section between the second and third test lines, a cup pipe was found at approximately 0.9m underground (Figure 10).

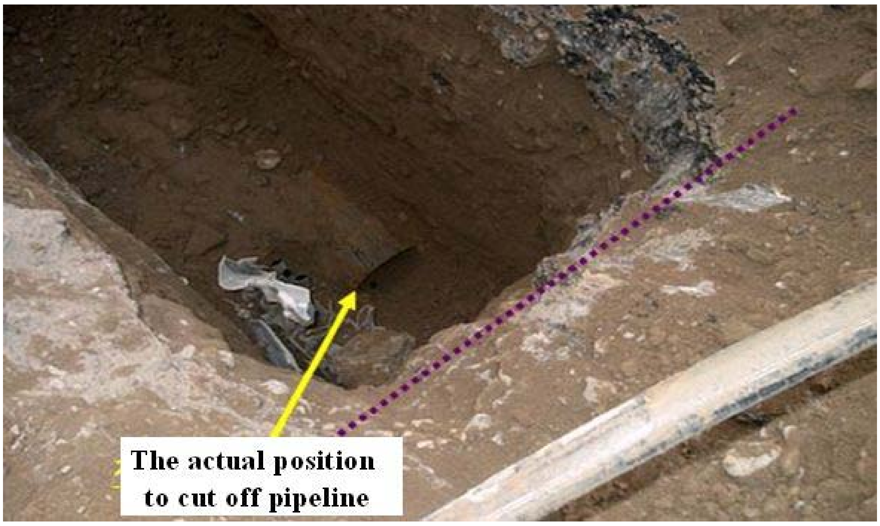

Figure 10. Photo of excavation result

CONCLUSIONS

The following conclusions were obtained from case results:

(1)The case research verified that there was a cut pipe underground at the area. The pipe was 10 cm in diameter and approximately 0.9 m underground.

(2)For a piping test, GPR is definitely a useful engineering tool with Non-Destructive Testing, fast and high-resolution features.

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