Locating Buried Engineering Structures Using Ground Penetrating Radar and Cable Locator Detector

İsmail DEMİRCİ [*,1], Burak KARAKÖSE[1]

[1] *Ankara University, Faculty of Engineering, Department of Geophysical Engineering*, TÜRKİYE
idemirci@eng.ankara.edu.tr

SUMMARY

Although it is easy to identify discontinuities on radargrams in the ground penetrating radar (GPR) method, there may sometimes be difficulties in completely determining underground engineering structures. The fact that the engineering structures are smaller in scale than expected makes it difficult to find the structure, while the presence of secondary engineering structures may be insufficient to completely determine the underground structures with the GPR method. The study focused on the covering effect of plastic pipes and engineering structures on each other in case of electrical transmission lines adjacent to these pipes and how they can be determined. It is aimed to view both engineering structures at the same time in the test site. GPR method was used to image the plastic pipeline. It has been deemed necessary to use a secondary method for the power transmission lines located right next to them and which cannot be displayed on radargrams due to the covering effect of the plastic pipe. For this reason, in addition to the GPR method, the RTK-Pro cable detection detector produced by the Vivax brand was used and the electrical transmission line, which could not be viewed due to the covering effect of the plastic pipe, could also be imaged. In this way, it is recommended to use more than one method at the same time, rather than single methods, in determining underground engineering structures. In case one of the methods was insufficient, both engineering structures could be found thanks to the other complementary method.

Keywords: Buried Engineering Structures, Ground Penetrating Radar, Cable Detector, Integrated Interpretation

INTRODUCTION

GPR method is a high frequency electromagnetic (EM) method. The biggest advantage of the method is that results with sufficient sensitivity can be obtained by using antennas with center frequencies suitable for the target research depth. Measurements are collected by recording the EM signal arriving at the receiving antenna as a function of time as a result of the reflection and scattering of the high-frequency electromagnetic (EM) source field sent into the ground at certain intervals on a profile hitting any discontinuity. After the data is processed, radargram sections sorted according to the positions of all traces are displayed. The most important advantages of the method are that it is easy to use and can collect data very quickly, it does not cause any damage to the study area during data collection, and it can perform two-dimensional (2D) and three-dimensional (3D) underground imaging with centimeter-level high resolution. Thus, it has become the most used geophysical method in all shallow surveys in recent years, as the location and depth of the structures can be determined much more clearly (Kadıoğlu 2008; Kadioglu and Daniels 2008; Kadıoğlu, 2017). Although it is easy to identify large-scale engineering structures on Radargrams, there is difficulty in identifying secondary engineering structures adjacent to these structures. Due to this problem, a secondary method was needed during the study. During the study, it was decided to use the RTK-Pro cable locator detector produced by the Vivax brand, distributed by SEBATEK, and the results were displayed. The working principle of this detector is based on the principle of determining the magnetic field created on a live or non-living electrical line, at a frequency of 50 Hz for our country or at any frequency we create with the help of a transmitter, with the help of magnetic sensors in the detector. In the method, it is possible to obtain information about the depth of the line based on the line route and initial amplitude by monitoring the amplitude of the electromagnetic signal at a specific frequency sent from the transmitter. Thanks to the use of both methods together, buried structures and their locations can be obtained effectively.

METHODS

Ground penetrating radar method is a high-frequency EM method used in near-surface research that enables high-resolution imaging of the underground. The basic measurement elements that make up the ground radar system consist of transmitting antenna, receiving antenna and recorder. High frequency EM source wave is sent into the ground with the transmitting antenna. Underground layers and buried objects have physical and chemical properties specific to their composition. These features cause buried objects or layers to have different physical properties than the environment in which they are located (dielectric permeability is a physical parameter in the method specific). Thus, the EM wave sent into the ground undergoes reflection and scattering when it encounters the surfaces of these buried objects or layers. From these reflected and scattered waves, those reaching the receiving antenna on the surface are recorded. The set of waves recorded as a function of arrival time is called the wave field. The EM wave sent to the ground has a harmonic structure and contains an active frequency. The value of this frequency determines the depth of penetration, the amount of absorption and the degree of scattering (Annan 2000). The success of the method depends on appropriate antenna selection, quality data collection, and good data processing and imaging. Antenna selection is made according to the depth and size of the object sought. Ground radar data is collected on parallel profiles that can intersect the searched object at at least two points. In the data-processing phase, the contents of frequencies considered noise are extracted from the data. Since the EM wave is absorbed with depth, wave amplitudes are increased depending on time and/or depth by using the appropriate method. If desired, the EM wave speed of the medium is determined using velocity analysis methods. In this way, one can switch from time slices to depth slices. Data-processed data can be presented as 2D and 3D images.

In addition to the GPR method, the RTK-Pro cable locator produced by the Vivax brand was used. The working principle of the method is based on the principle of sending the electromagnetic field we create with the help of a transmitter to a living or non-living electrical or metallic pipeline and recording it back by the receiver. With the help of magnetic sensors in the receiver, the amplitude of the electromagnetic field at 50 Hz for city electricity or a specific frequency given from the transmitter is found and used to monitor the depth and line length of the line (Figure 1). In the method, if work is to be done on lines that are not included in the electrical transmission lines, measurements can be taken after creating an AC electromagnetic field with the help of the transmitter and turning it into a closed circuit.

CONCLUSIONS

During the study, data were collected for testing purposes to determine the location and position of the rainwater collection line located in Ankara University Gölbaşı campus and the electrical line of the pump to be used during the reuse of stored water. The area where the study was carried out and the relevant line structure are shown in Figure 2. First of all, in order to determine the pipeline, GPR data was collected along 7 lines parallel to each other and passed through the data processing phase. The resulting data is given in Figure 3 by creating a 3D cross-section. When the cross-sections obtained were examined, it clearly showed that the location of the power line lying right next to the pipeline could not be determined. Thereupon, the RTK-Pro cable locator detector produced by the Vivax brand was used in order to find the location and depth of the line, whose location and location had been measured precisely and indicated by the continuous red line in Figure 4. In the method, an EM wave at a special frequency was sent to the ground from the surface part of the cable with the help of the transmitter shown in Figure 1, and the propagation of this EM wave was followed with the help of the receiver and its location and depths were obtained. The data obtained were compared with the location and depths before burial. When the measurement sensitivities were examined, it was seen that an accuracy of cm was achieved. In this way, it has been suggested that both methods be used together in determining underground transmission lines before important excavations for industrial facilities and municipalities.

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REFERENCES

Annan AP (2000) Ground Penetrating Radar Workshop Notes. Sensors and Software Inc., Canada.

Kadioglu S (2008) Photographing Layer Thicknesses and Discontinuities in a Marble Quarry with 3D GPR Visualization. Journal of Applied Geophysics, 64 (3), p. 109-114.

Kadioglu S and Daniels JJ (2008) 3D Visualization of Integrated Ground Penetrating Radar Data and EM-61 Data to Determine Buried Objects and their Characteristics. Journal of Geophysics and Engineering, 5, p. 448-456.

Kadioglu S (2017) Research of the sea-filled airport OGU in the Black Sea, Turkey, using ground penetrating radar method, Construction and Building Materials.Special Issue on Ground-Penetrating Radar and Complementary Non-Destructive Testing Techniques in Civil Engineering, Vol 158, 1123-1133.

Figure 1 *RTK-Pro Receiver and transmitter unit*

Figure 2 *Images of the searched pipe and cable line before being buried*

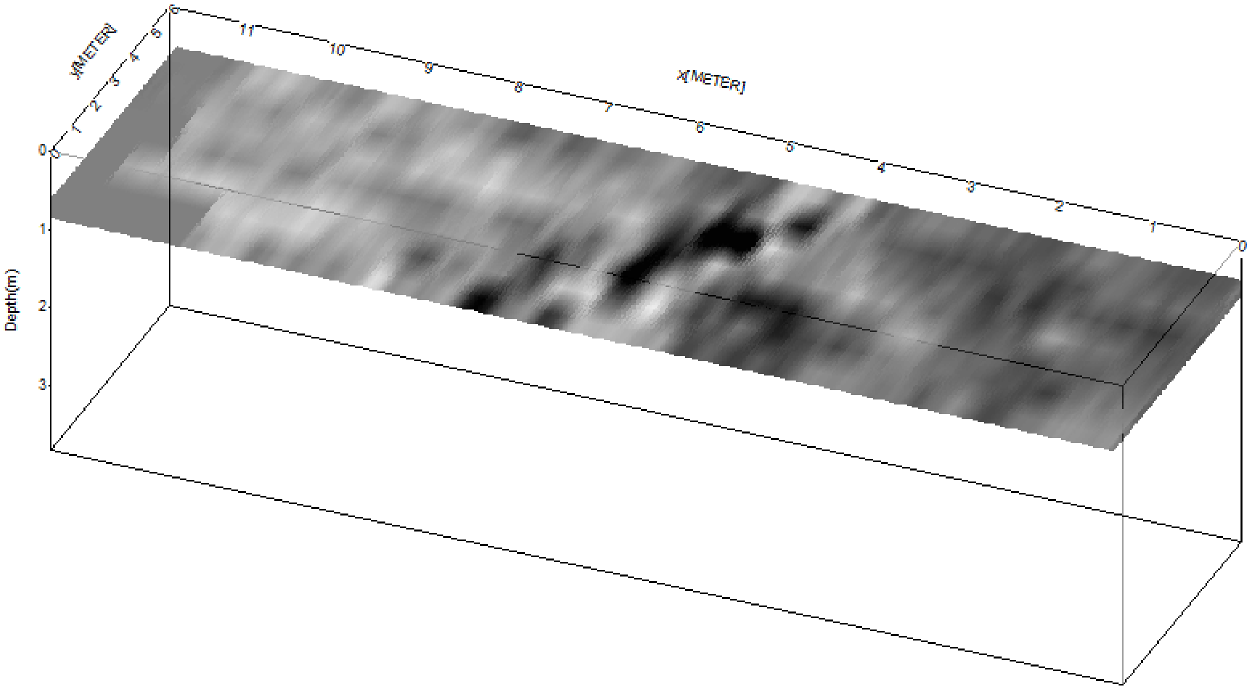

Figure 3 *3D GPR depth slice of 70 cm depth level*

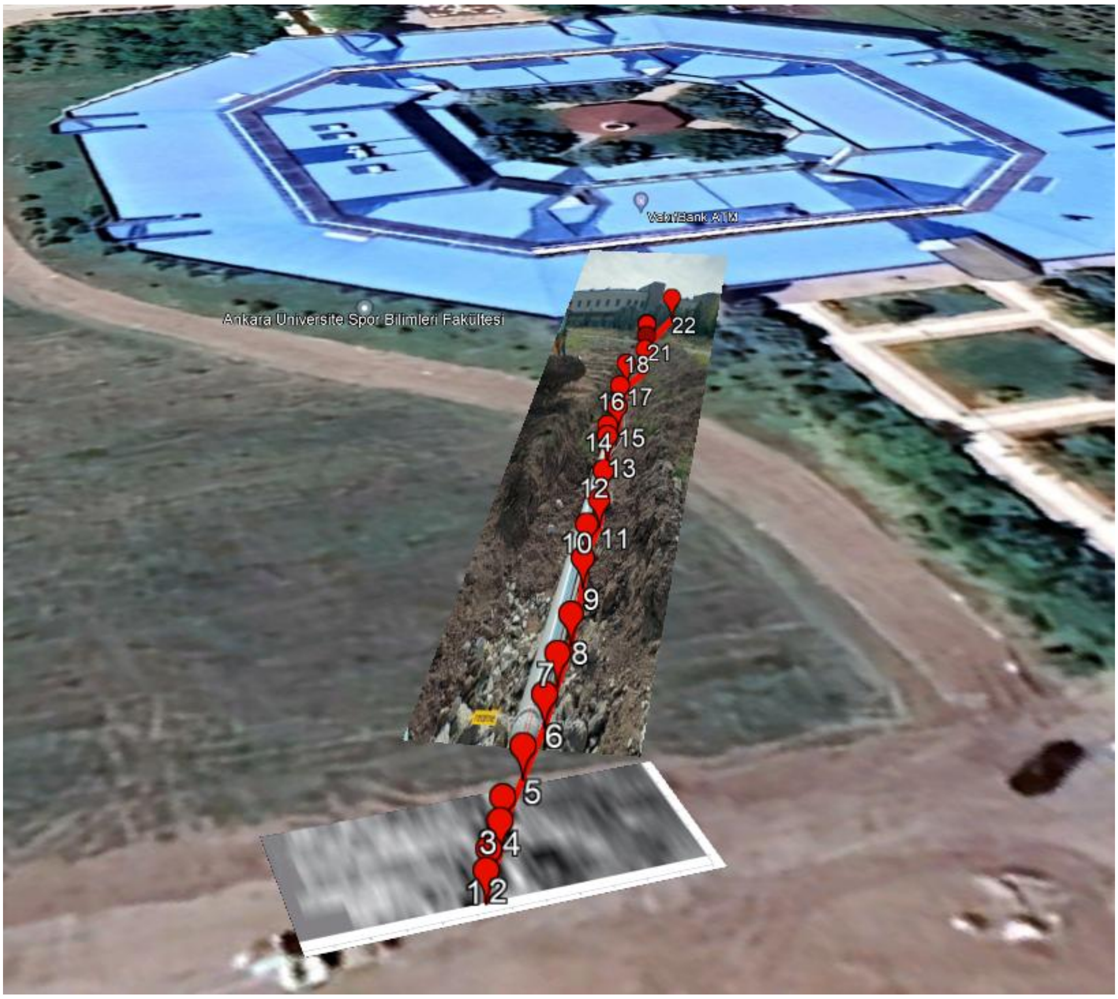

Figure 4 *Study Area, pipelines and cables displayed superimposed on Google Earth*