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Proceedings

DEPTH OF DETECTION IN RESISTIVITY SURVEYS. A CASE STUDY OF A RESISTIVE BURIED TARGET

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INTRODUCTION

There are in the literature several examples of experiences for detection of buried structures, both in physical (e.g. Apparao, et al., 1992, 1997 a and b) and computer modelling (Coggon, 1973). The objective of the present study was the evaluation of DC resistivity surveys limitations for detection of a buried resistive structure in a natural environment. To fulfil this objective, several profiles using Wenner Continuous Vertical Electrical Soundings (CVES) and Dipole-Dipole array were performed in a landfill for a highway in Portugal.

The structure to be detected was a buried drainage concrete pipe with a 2 m diameter. The profiles were carried out crossing the pipe at two sites near to its edge (4 m apart from each other), which allowed us to have two depths of investigation (Fig.1). Three dipoles spacing were used in location A and two at location B. The ratio between the thickness of the layer overlying the pipe and its diameter (D) was 0.825D at location A and 1.860D at location B. The pipe was installed in a small karst valley filled with compacted layers of stones, gravel and sand, which composed the host medium. The largest profiles reached the natural terrain while the smaller ones were performed all over the landfill deposit.

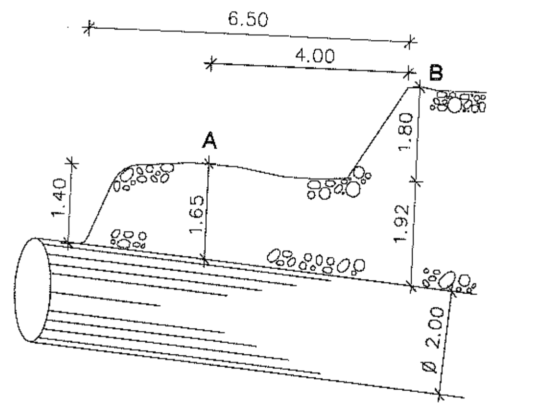

Fig.1 Diagram of pipe position, with profiles locations (marked by A and B) and depth to the pipe (m).

FIELD PROCEDURE

The equipment used to perform the survey was an ABEM Lund Imaging System (Griffiths et al., 1990; Dahlin, 1996). The survey took place in June (Summer), and the soil was dry. The dipole spacing used at location A was 0.5, 1.0 and 2.0 m, and at location B it was used 1.0 and 2.0m. So, the dipole spacing-pipe diameter relation was, respectively, 0.25D, 0.5D and 1.0D.

RESULTS AND DISCUSSION

The measured apparent resistivity pseudosections were inverted using the Res2DInv software (version 3.4) (Loke and Barker, 1996; Loke, 1999). The finite element method was used for the model response calculation (forward modelling) and a combination of the Marquardt and Occam approaches was used for the inversion procedure, resolving the partial derivatives for each iteration.

Although topographic relief is only present in part of the larger profiles topography data was incorporated into the resistivity models in order to minimise topographic effects (Fox *et al.*, 1980; Tsourlos *et al.*, 1999). For the topography it was considered at each location that the flat surface was at level 0.0 and the elevation from the flat surface was the topographic data. The ten models obtained are presented in figures 2 and 3, with the Dipole-Dipole array models at the left and the Wenner array at the right.

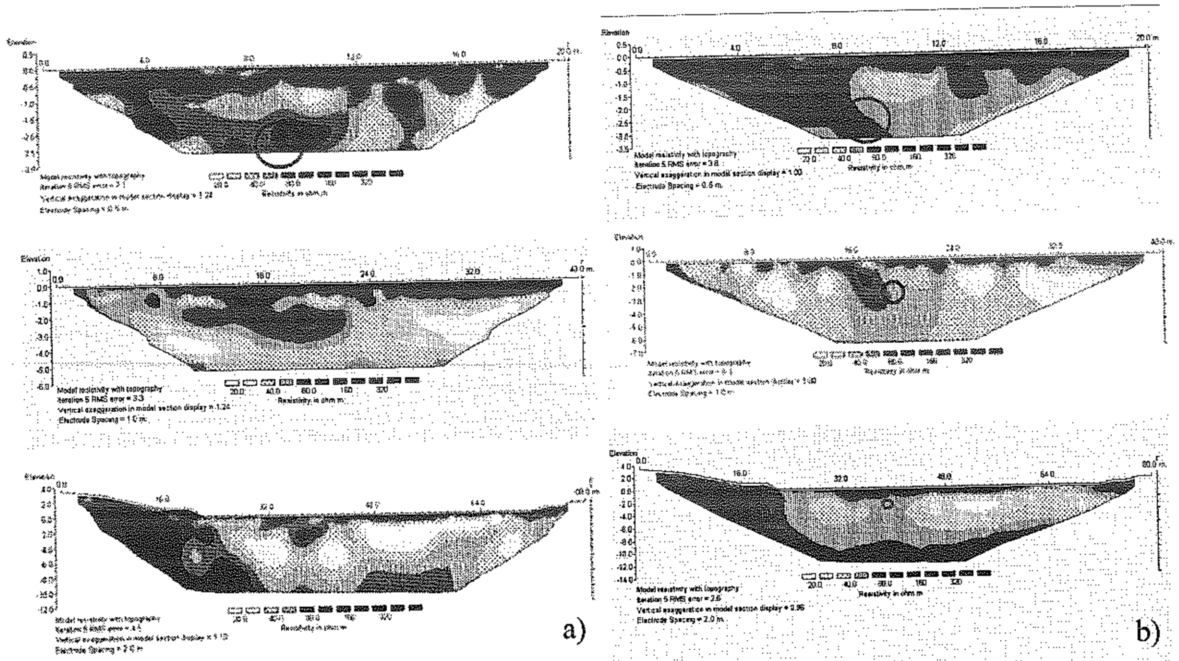

Fig. 2 Inversion results for location A (a – Dipole-Dipole array, b – Wenner array).

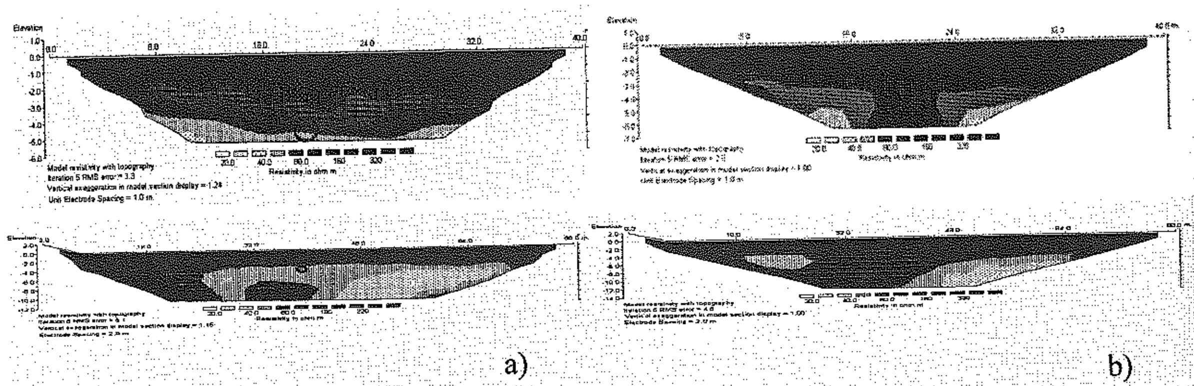

Fig. 3 Inversion results for location B (a – Dipole-Dipole array, b – Wenner array).

In figures 2 and 3 the tube is represented at the same scale as the dipoles (horizontal scale), since the vertical scale differs from model to model.

Based on tank models Apparao et al. (1997b) states that for Wenner array the detection depth is 1.5 times the cylinder radius (1.5R) or 0.75 times its diameter (0.75D) and for the Dipole-Dipole array these relations are 2.0R and 4.0D, respectively. In this study the relation depth-tube diameter was equal to 0.825D, at location A, and 1.860D, at location B.

From the results shown in figures 2 and 3 one can see that the tube is well detected only with the Dipole-Dipole array at location A, whatever was the dipole spacing used. At location A one can say that the Wenner array seems to detect "something", as at the known location of the tube a resistivity rising can be noted, specially with the dipole spacing of 0.5 and 1.0 m. The value of the depth of detection in this study is inferior to that one estimated by Apparao and his co-authors' results (1997b).

Nawawi and Loke (1995) presented a similar field case with a 2 m diameter concrete tube located at 3 m depth and performed with a Wenner array with 2 m electrode spacing. In this case the anomaly due to the tube was well delimited. In the resistivity model the relation between $\rho_a$max and $\rho_a$min was $\rho_a max = 15 \rho_a min$. In our inversion results we have a relation of $\rho_a max = 7 \rho_a min$.

Taking in mind the Van Nostrand's (1953) conclusion, that a buried target can be detected if it produces at least a minimum of 10 % anomaly, the Apparao et al.'s (1997b) and Nawawi and Loke's (1995) results, one can conclude that the reason for not having detected the concrete pipe, for all the situations considered in this study, is that the host medium had a resistivity of almost the same order of magnitude as the pipe, probably due to the low water saturation degree associated to the high porosity and to the hot and dry season when the study was performed.

From this study one can conclude that the best array for detection of resistive buried pipes in a dry environment is the Dipole-Dipole, for any dipole spacing between 0.25D and 1.0D, but with a depth-tube diameter relation around 1.0D.

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