

APPLICATION OF 2D ELECTROMYOGRAPHY IN THE STAGE OF ENGINEERING AND GEOLOGICAL SURVEYS ON A CONSTRUCTION SITE

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ABSTRACT. Electrical Resistivity Tomography (ERT) is a widely used geophysical method for near-surface characterisation of geological conditions in engineering and environmental studies. This paper presents the results of an ERT investigation conducted at a construction site (store No. F178) in the town of Dupnitsa, Southwestern Bulgaria. The study aimed to delineate the thickness and lateral extent of anthropogenic fill materials and to estimate the groundwater level within the upper 10–15 m of the geological section. Three ERT profiles with a total length of 146.5 m were measured using a four-electrode Schlumberger array and interpreted through two-dimensional inversion. The obtained geoelectrical models reveal three distinct resistivity zones corresponding to construction waste fill, clay-rich fill material, and water-saturated alluvial deposits.

Key words: 2D Electrical resistivity tomography, ERT, engineering geology, groundwater, alluvial deposits.

ПРИЛОЖЕНИЕ НА 2D ЕЛЕКТРОТОМОГРАФИЯТА В ЕТАПА НА ИНЖЕНЕРНОГЕОЛОЖКИТЕ ПРОУЧВАНИЯ НА СТРОИТЕЛНА ПЛОЩАДКА

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РЕЗЮМЕ. Електротомографията (Electrical Resistivity Tomography, ERT) е широко използван геофизичен метод за изследване и характеризиране на приповърхностните геоложки условия при инженерногеоложки и екологични проучвания. В настоящата статия са представени резултатите от ERT изследване, проведено на строителна площадка (обект № F178) в гр. Дупница, Югозападна България. Основната цел на проучването е да се определят дебелината и страничното разпространение на антропогенните насипни материали, както и да се оцени нивото на подземните води в горните 10–15 m от геоложкия разрез. Измерванията са извършени по три ERT профила с обща дължина 146,5 m, използвайки четириелектродна схема Schlumberger, а данните са интерпретирани чрез двумерна инверсия. Получените геоелектрични модели разкриват три ясно обособени зони по електрично съпротивление, съответстващи на насип от строителни отпадъци, глинесто насипно тяло и водонаситени алувиални наслаги.

Ключови думи: 2D Електротомография, ERT, инженерна геология, подземни води, алувиални наслаги.

Introduction

Reliable characterisation of subsurface conditions is essential for engineering design and construction planning. Conventional drilling provides accurate point information but often lacks sufficient spatial coverage. Electrical Resistivity Tomography (ERT) complements borehole investigations by providing continuous two-dimensional images of subsurface resistivity variations.

The research results of ours and of other Bulgarian authors in the last two decades have shown the great applicability of the ERT method in mapping geological and hydrogeological sections, karst and fractured zones, tectonic disturbances, areas with different water saturation or different degrees of pollution, landslides, mining sites, etc (Tzankov and Demireva, 2013; Grigorova and Koprev, 2018; Stoyanov and Dimovski, 2020; Georgieva et al, 2021; Tomova, 2023).

The present study was carried out at a construction site No. F178 located at a north site of Dupnitsa. The site is situated on the left-bank terrace of the Bistritsa river, a major tributary of the Dzherman river (Fig. 1). The terrain is flat, with an altitude of 500 m.

The main object of the ERT investigation was to specify a geological fault to a depth of 10 – 15 m, by mapping possible spatial outline of the embankment and marking the probable depth of the underground water, at the moment of the survey.



Fig. 1. Location of the survey area (from the data of the Google Earth)

Geological setting

The investigated area is located within the alluvial valley system formed by the Dzherman river and its largest tributary, the Bistritsa river (Fig. 2). The geological structure is dominated by alluvial deposits consisting mainly of gravels, coarse sands, fine sands, and clay-rich sediments (Sarov et al, 2011). The upper portion of the fault is composed of fine-grained sands, clay sands, and sandy clays, while underneath them are the deposits that contain coarse-grained large and medium gravel with sandy matrix material. The alluvial sequence reaches approximately 10–15 m in thickness.

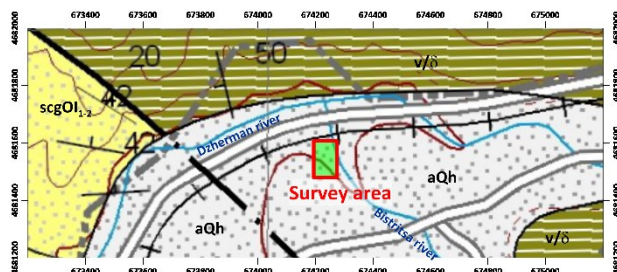


Fig. 2. Geological map of the region (from Geological map of Bulgaria M 1:100000. Map sheet K-35-40 Tvarditsa, Sarov et al, 2011).

In the region of the survey area, natural soil is covered by the embankment, which according to data from constructed exploratory boreholes is with a thickness of around 5 – 6 m. Fig. 3 shows the locations of the five exploratory boreholes done by the Terra Drill Group company.

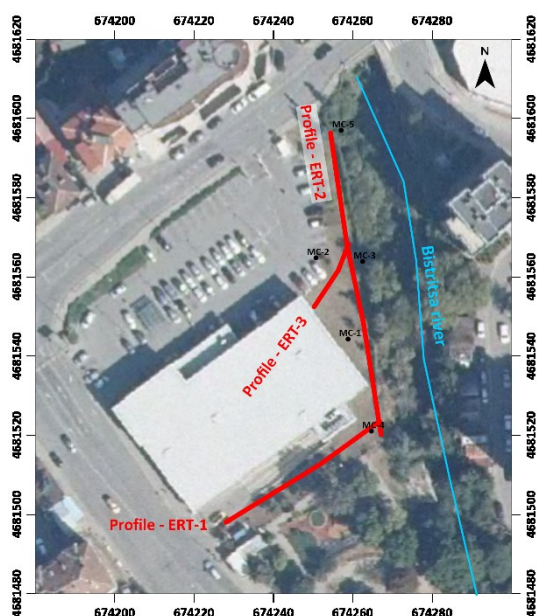


Fig. 3. Location of the geophysical profiles (ERT-1, ERT-2, ERT-3) and borehole locations (MC-1 ÷ MC-5)

Methodology

Principles of electrical resistivity tomography

Electrical resistivity tomography (ERT) is based on measuring the electrical resistivity distribution of subsurface materials. Electrical current is injected into the ground through two current electrodes (C1 and C2), while the resulting potential difference is measured between two receiving electrodes (P1 and P2). The mostly used electrode placement schemes are the Wenner and the Wenner – Schlumberger schemes, dipole – dipole, pole – pole, and pole – dipole schemes. The data obtained during those measurements is processed by the RES2DINV specialised software (Loke, 2001). In the end, apparent resistivity values are subsequently inverted to obtain a model of true subsurface resistivity.

Resistivity contrasts are commonly associated with changes in lithology, porosity, moisture content, groundwater saturation, and anthropogenic disturbances.

Field measurements

Three ERT profiles were measured (Fig. 3):

- ERT-1: 46.0 m long;
- ERT-2: 80.5 m long;
- ERT-3: 20.0 m long.

The total profile length was 146.5 m.

Measurements were performed using an ABEM Terrameter SAS 1000 resistivity system (Fig. 4). The instrument operates with an output voltage of up to 450 V and a maximum current of 1000 mA. Data acquisition employed a four-electrode Schlumberger configuration connected through multi-core cables.



Fig. 4. Electrical resistivity equipment

Data processing

The data obtained from the field measurements are processed using the RES2DINV computer program (Loke, 2001). As input data, the information entered into the program is the positions of the electrodes on the surface and the apparent resistivity values at each measurement point. Based on this information, a 2D model of the subsurface is constructed, with the program automatically dividing the subsurface space into a large number of blocks. Subsequently, using the least-squares method, the resistivity of each block is determined in such a way that the apparent resistivity calculated from the model matches the measured electrical field as closely as possible (Loke and Barker, 1996).

As a final result, the RES2DINV program produces three vertical sections:

1. Measured apparent resistivity pseudosection;
2. Calculated apparent resistivity pseudosection;
3. Inverse model resistivity section.

The comparison of the two former sections illustrates the reliability of the model solution, while the latter section provides the actual distribution of electrical resistivity within the subsurface.

The determined geoelectrical model is transformed into a geological model on the basis of:

- General information for geo-tectonic, engineering geological and hydrogeological conditions of the study area;
- Data from engineering geological observations and from an executed borehole survey (in this case, from 5 exploratory drills in the survey area, MC-1 ÷ MC-5);

- Published resistivity ranges for common geological materials (Daniels and Alberty, 1975; Keller and Frischknecht, 1996).

Results

The inverted ERT sections reveal significant resistivity contrasts within the upper part of the investigated geological section. Resistivity values range from approximately 7 Ω m to more than 1000 Ω m.

Three major geoelectrical zones were identified.

Zone A: High-resistivity layer

The uppermost zone exhibits resistivity values between 150 and more than 1000 Ω m. This layer is interpreted as construction debris fill consisting predominantly of large to medium-sized fragments. The thickness generally varies between 1 and 3 m, averaging approximately 2–2.5 m (Fig. 5).

Zone B: Intermediate-Resistivity Layer

The second zone displays resistivity values between 50 and 150 Ω m. It can be interpreted as a lower part of the construction fill embankment, represented by small- to medium-sized pieces with clay matrix, probably with a high level of water saturation. The thickness varies from approximately 1 m to 5 m, with average values around 3–4 m (Fig. 5).

Zone C: Low-Resistivity Layer

The deepest identified zone is characterised by resistivity values ranging from 7 to 50 Ω m, rarely outside these limits. Most likely, this zone maps alluvial deposits, on which the construction fill embankment lies. This zone is composed of gravel and sand with sandy-clay matrix material, and it is a water-saturated zone (Fig. 5).

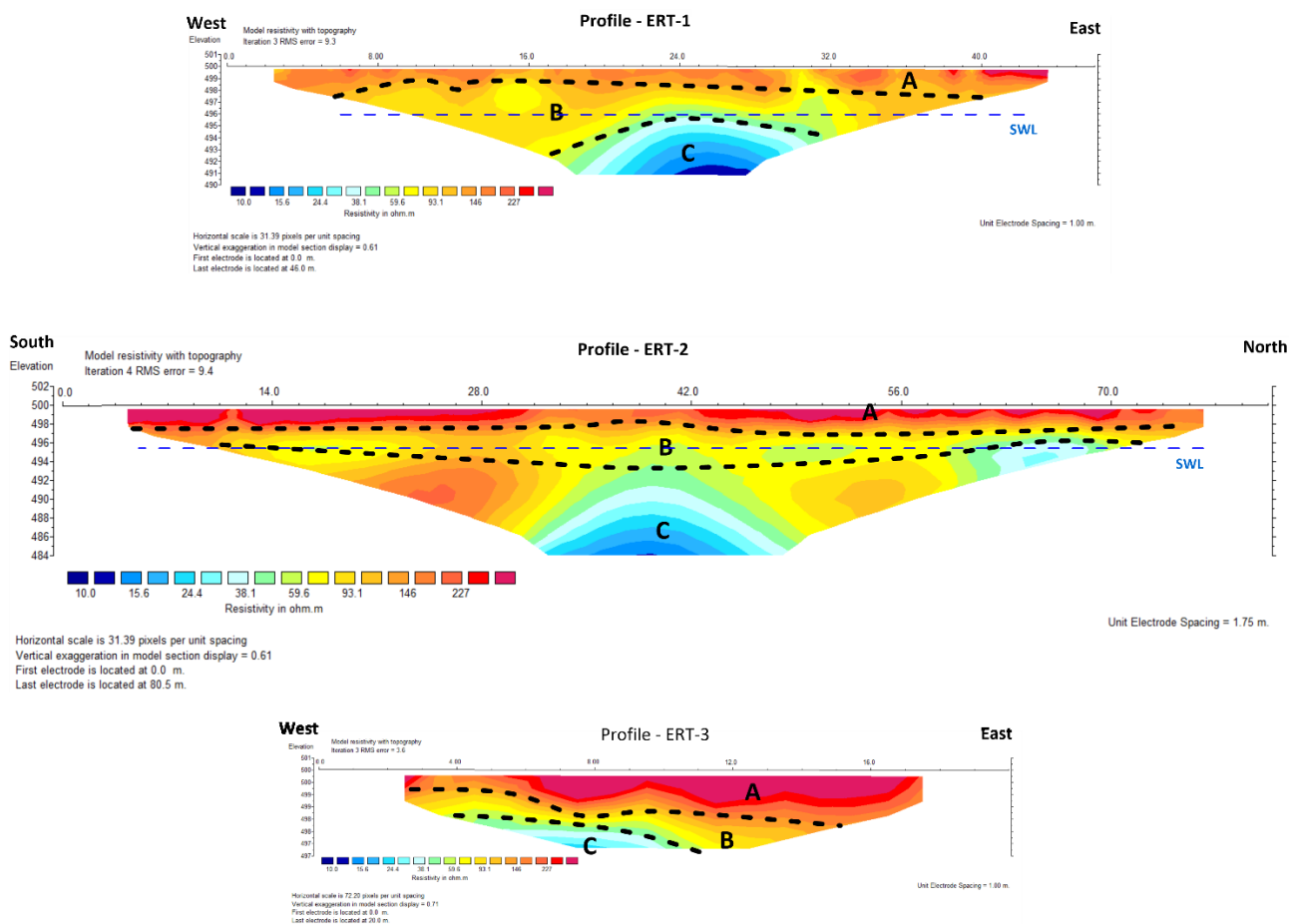


Fig. 5. Segmentation of an electrical resistivity section along geophysical profile ERT-3 (the situational plan is presented in Fig. 3)

Conclusion

The conducted ERT survey provided valuable information regarding the shallow subsurface structure of the investigated construction site in Dupnitsa.

The main important conclusions, made from the complex analysis of the results obtained from the ERT survey (Fig. 5) and

taking into account the general geological and tectonic information for the studied area, the data from the engineering geological survey, and the data from the documented geological section in the constructed exploratory boreholes MS-1, MS-2, MS-3, MS-4, and MS-5 are:

1. The geoelectrical section is very well endured in terms of the distribution of electrical resistivity in depth.

2. The electrical resistivity of the media that makes up the studied geological section varies in a wide range from 7 m to 1000 m and more.
3. In the most general sense, the studied geoelectrical section is represented by three electrical resistivity environments (zones), mapping areas with different composition, genesis, and degree of secondary alteration of the geological environment.
4. The geoelectrical sections along geophysical profiles ERT-1 and ERT-2 and the registered water levels in the Bistritsa River suggest that at the time of measurement the groundwater level was at a depth of 4.0 - 4.5 m. In Fig. 5, the assumed distribution of piezometric (water) levels is represented by a dashed blue line.

The study confirms the usefulness of Electrical Resistivity Tomography for rapid characterisation of complex near-surface geological conditions in urban construction environments.

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