3.1 NON- DESTRUCTIVE GEOPHYSICAL INVESTIGATION OF SUPPORT STRUCTURE ELEMENT BY USING 3D INVERSION OF DIRECT CURRENT RESISTIVITY DATA

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ABSTRACT

The multi-electrode and multi-channel resistivity measurement systems has long been used for Direct Current Resistivity (DCR) measurement to investigate underground resistivity structures. Although small-scale DCR studies are generally preferred in laboratory research, they are also used in the examination of structural system elements of reinforced concrete engineering structures such as buildings, bridges, etc. In this study, a new data measurement tools with multi-electrode DCR measurement systems that is suitable for small scale measurement on concrete structures was developed. In addition, different electrode array setup for concrete structure investigation taking into account the measurement time and the inversion results of synthetic data were compared. First, the 3D resistivity models generated for the concrete structure contains iron reinforcement, cracks and a moist region. For this model, we calculated sythetic data with 3D modeling for the different electrode layout that are positioned on a single surface, opposite surfaces and adjacent surfaces on a columnar structure. DCR data collected on the column structure with the developed measurement tools and determined electrode layout according to synthetic study. Measured data inverted by using 3D inversion algorithm that use unstructured finite element mesh. The synthetic and field data studies showed that it is possible to determine the concrete cover thickness of the element, the distribution of reinforcement within the element and possible fracture/crack/humidity conditions by applying the DCR method on the structural load-bearing elements

KEY WORDS : Direct Current Resistivity, Small-scale application, Construction Geophysics, 3D inversion

INTRODUCTION

The earthquakes damage the conrete structure such as buildings and bridges. In order to decide whether buildings can be used after the earthquake or not, it is very important to investigate damaged parts of load-bearing structural elements in a short time. Non-destructive geophysical methods, such as ultraseismic, structure radar and structure DC resistivity methods, are main tool for this kind of investigation (Candansayar, 2012). In this study, we used multi-electrode and multi-channel resistivity measurement systems for structure investigation. We first investigated the most suitable electrode arrays, and electrode layouts on a single side, opposite side and adjasent side by uisng 3D modeling and inverison algoritmh. We calculated synthetic data with 3D modeling algorithm for column model. We added %2 Gaussian noise to data and invert it by using 3D inversion algortihm. We used R3t modeling and inversion algorithm based on unstructured tetrahedron finite element mesh (Binley, 2013).

As real data, we collected DC resistivity data on column for three different electrode layout: on a single surface, on opposite surfaces and on adjacent surfaces. 3D inversion was performed by adding noise to the synthetic data obtained as a result of modeling studies.

METHOD and APPLICATION

The basic principle of the DCR method is to measure the potential difference between two pair of potenrtial electodes created by the direct current applied to the ground from two pair of current electrodes. The purpose of the method is to map the resistivity structure of the investigated area or region of the structures according to the electrical resistivity parameter.

DISCUSSION and RESULTS

First, a column model was designed to be used in synthetic data applications (Figure 1). In order to be more realistic, structures representing longitudinal reinforcement and stirrups were placed into the column model. In the model, the resistivity of the concrete is determined as 100 ohm.m and the resistivity of the reinforcement is determined as 1 ohm.m.

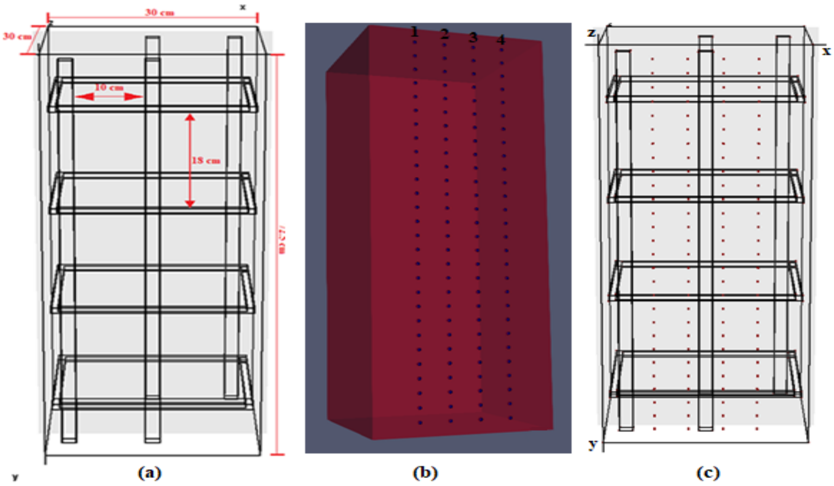

Figure 1 (a) Schematic representation of the distribution of stirrups and longitudinal reinforcements within the column model (b) Demonstration of the distribution of electrodes on a single surface on the column model (1,2,3,4: Profile numbers) (c) representation on the structures within the model (electrode spacing 2.5 cm, profile spacing 5 cm)

Afterwards, sounding profiling data on a single surface electrode layout with 112 electrodes (4x28) for Wenner and Dipole-dipole electrode arrays (Arıcan, 2023) was calculated. The inversion result for each array given in Figure 2. When the inversion results are compared with the column model, it is seen that the DD array gives better results than the Wenner array.

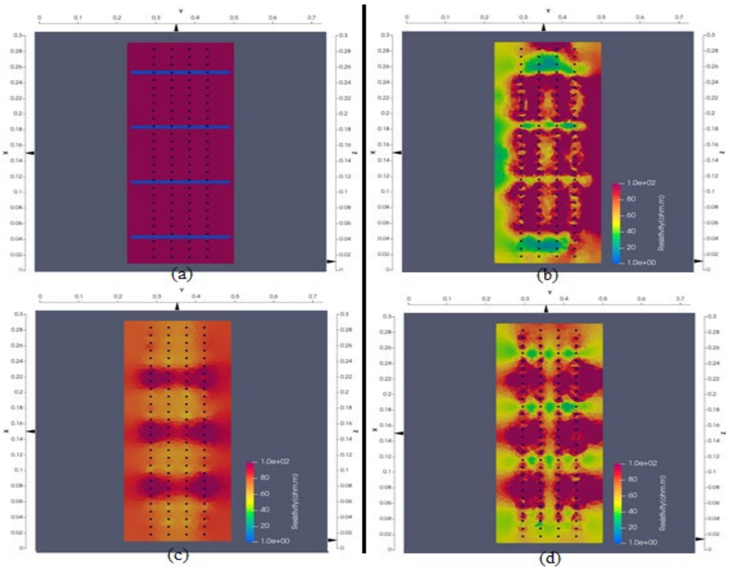

Figure 2 xy-resistivity sections for z=1 cm depth: (a) real model (b) DD array 3D inversion result (c) W (n=1 level) array 3D inversion result, (d) W (n=1 and 3D inversion result of the sequence) for level 2.

In addition to the studies in which the electrodes were located on a single surface of the column model, modeling and inversion studies were also carried out for the situation in which the electrodes were located on the adjacent (front and left) surfaces (Figure 3).

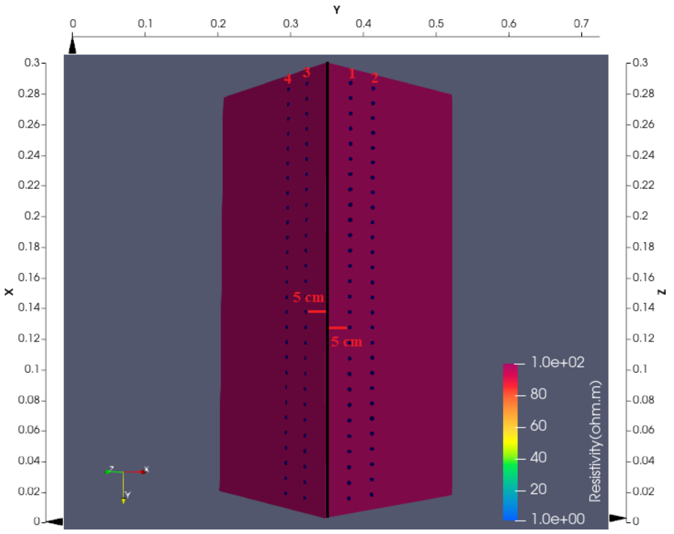

Figure 3 The black line is the intersection of the front and left surfaces, and the representation of the electrodes on the front surface, located 5 cm away from the edge in the x direction, and on the side (left) surface, located 5 cm away from the edge in the z direction, on the model (1,2,3,4: profile numbers).

In the studies carried out on adjacent surfaces, inspired by the cross-gole DCR measurement, investigations were also carried out for situations where the profiles on two different surfaces were considered as one well. In the examinations, the pol-tripole (PT, ABMN) electrode array recommended by Demirel and Candansayar (2017) was used. The inversion result for DD,PT arrays and different location of electrodes on the adjacent sides of column given in Figure 4. In the 3D resistivity models of the PT array, it is seen that the artificial effects and the effects in the regions where there are no electrodes are reduced and a resistivity distribution closer to that of the real model is obtained in these regions.

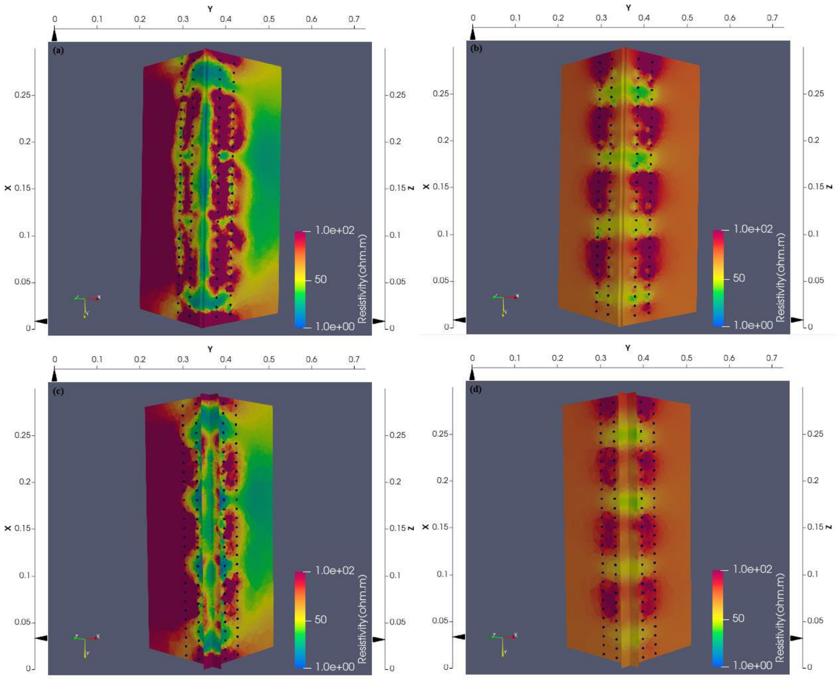

Figure 4 From the 3D resistivity models obtained when the electrodes are 5 cm away from the edge, (a) Dipole-Dipole (b) x = 1 cm and z = 1 cm for PT arrays, (c) DD (d) x = 3 cm and Sections taken from z = 3 cm

CONCLUSION

When collecting data in structural geophysics, W Array with 5 cm electrode spacing is generally used. In this study, W, DD, PD sequences measured on a single surface were compared. It has been shown that PD data collected on one surface gives better results than other arrays. It is shown that the PT array data gives better results than the others when the inversion results obtained for adjacent surfaces and a single surface are compared. Inversion results of real data collected on a column also support the synhetic data results.

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