

CHAPTER

3

ELECTRICAL RESISTIVITY TOMOGRAPHY FOR CONCRETE ANOMALIES DETECTION

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3.1 INTRODUCTION

Concrete is a widely used construction material in structural systems due to its high compressive strength and long service life. However, internal anomalies such as voids, honeycombing, poor compaction, and foreign inclusions can compromise the mechanical integrity of concrete elements over time (Gulati & Shah, 2021). These defects are often hidden and inaccessible, making their detection a challenge using conventional visual or destructive testing methods. In recent years, Non-destructive Testing (NDT) technologies have gained attention as effective alternatives for internal structural evaluation, with Electrical Resistivity Tomography (ERT) emerging as one of the most promising techniques (Jeon & Yoon, 2024; Yang et al, 2023; Sun et al., 2025).

Electrical Resistivity Tomography (ERT) enables the imaging of subsurface resistivity variations by injecting a controlled electrical current through selected electrode pairs and measuring the resulting voltage at other electrode combinations. From this data, internal resistivity distributions can be inferred, allowing for the detection of features such as cracks, moisture, or non-conductive inclusions. The principle is based on

Ohm's law and the sensitivity of voltage distribution to subsurface resistivity changes. While ERT has its roots in geophysical applications, it is increasingly adapted for smaller-scale, high-resolution investigations in civil engineering (Sun et al., 2025; Yang et al, 2023).

3.2 ELECTRICAL RESISTIVITY TOMOGRAPHY MEASUREMENT PROTOCOLS

In this study, a preliminary experiment was designed using a cylindrical acrylic model embedded with 16 equally spaced stainless-steel electrodes around its circumference. Two test scenarios were compared: a solid homogeneous medium and one containing a centrally placed 50 mm diameter PVC or Styrofoam core to simulate a defect. The goal was to determine whether ERT could differentiate between the two internal conditions based solely on voltage measurements.

To perform the measurements, two common ERT protocols were considered, both illustrated in Figure 3.1. In the adjacent method (Figure 3.1a), current is injected between two neighbouring electrodes, and voltage is measured across nearby adjacent pairs. This setup generates shallow current paths, making it suitable for near-surface detection. The pattern is rotated sequentially through all 16 electrode pairs, ensuring full coverage of the circular domain (United State Environmental Protection Agency, n.d.)

In contrast, the opposite method (Figure 3.1b) injects current between electrodes located on opposite sides of the cylinder. This configuration creates deeper, more symmetrical current paths, increasing sensitivity to central anomalies such as voids or foreign inclusions. In this study, the opposite-pair injection method was adopted to improve the likelihood of detecting the centrally embedded non-conductive core (Balasco, et al., 2022).

Through this systematic approach, the study aims to explore ERT's viability as a practical NDT technique for internal inspection of concrete columns, offering an accessible method for early-stage anomaly detection in civil structures.

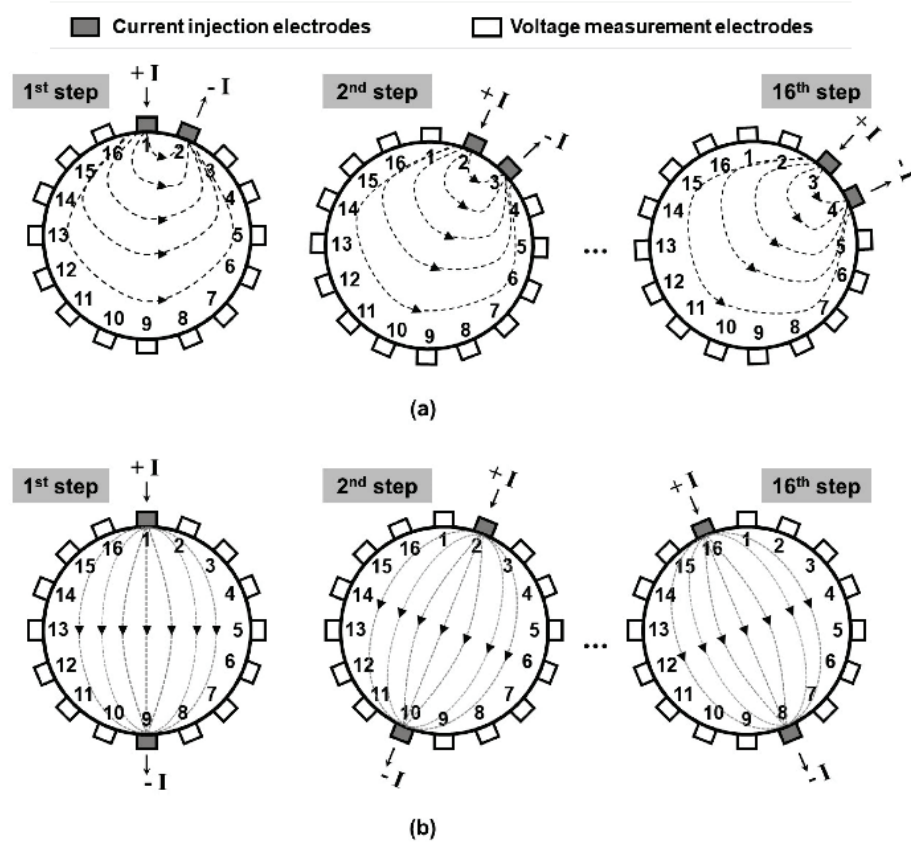


Figure 3.1 Common ERT measurement protocols using a circular 16-electrode array: (a) Adjacent electrode method and (b) Opposite electrode method

3.2.1 Electrode Array and Fabrication

A transparent cylindrical container with a diameter of 150 mm was fitted with 16 stainless steel electrodes, uniformly distributed along the circumference (22.5° apart). The electrodes were mounted using bolts and washers (Figure 3.2) and connected with insulated wires via crimped ring terminals for reliable contact.