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Perspective

Two-Dimensional Electrical Resistivity (ER) Technique for Dam Safety Assessment

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DESCRIPTION

To prevent unexpected failure and the collapse of engineering infrastructure, safety assessment tests on civil engineering constructions like dams, tunnels, and bridges are a must. Old dams that have outlived their salvage value or new dams exposed to natural disasters may have had mechanical property deterioration, which can result in structural damage that may not be immediately apparent. If such defects are not discovered by routine safety inspections and treated promptly, they may worsen and ultimately result in the breakdown of the dam. A dam is a structure built to control, direct, or prevent the free flow of water. Construction of dams is done for a variety of reasons, such as irrigation, water supply for people and industry, hydroelectric power production, flood control, fish breeding, recreation, and navigation. A dam failure can result in flooding, a lack of water, and a significant loss of lives and property.

Drilling and sample testing are two of the outdated techniques for examining dams for structural problems. In most cases, 250-300 mm hole(s) are bored in specific dam sections, and the samples obtained are structurally analyzed and tested in a lab. Drilling can only provide a limited amount of information about potential structural anomalies or dam issues, despite the expense and effort involved. Seismic, Ground Penetrating Radar (GPR), and electrical resistivity technologies are among the geophysical techniques frequently employed for dam investigation. These techniques can reveal structural irregularities such as fractures, faults, cracks, pipes, voids, traps, seepages, channels, sinkholes, cavities, etc. that could jeopardize the safety of the dam.

The greatest geophysical technique for studying dams is the Electrical Resistivity (ER) technique. Due to a resolution issue, GPR may produce incorrect results when the foundation is deeply submerged in water. The foundation of the dam or the basement rocks surrounding it may be further weakened by the destructive sources that are frequently used in seismic methods (such as explosives and heavy hammers). The most effective geophysical technique for investigating and monitoring dams is two-dimensional electrical resistivity, or 2D-ER. The technique is economical and has been successfully used to assess the foundation rock's suitability before dam construction as well as for safety tests after dam construction.

An array of electrodes (usually 64) connected by multicore wire is used in 2D resistivity imaging to produce a linear depth profile, or pseudo section, showing the resistivity variation both along the survey line and with depth. Using a laptop computer and relay box, the current and potential electrode pairs are automatically switched. The computer moves the pairings along the line until it reaches the final electrode while initially maintaining a set distance between the electrodes. To provide a deeper level of research, the spacing is then increased and the process is repeated.

The method is very helpful for investigating significant sites to learn about weak zones or hidden channels beneath the rock interface that are missed by seismic refraction that ceased at the rock interface. In high velocity, shallow rivers where the deployment of hydrophones is impractical, resistivity imaging can also be used to estimate the rock profile along the dam axis to circumvent the use of seismic refraction. Explosives are needed for seismic refraction techniques to penetrate deeply, but they are not always practical to use, especially in sensitive places. Resistivity imaging can be utilized to obtain precise information on deeper layers under these circumstances.

The various applications of 2D electrical resistivity are in mineral prospecting, contamination source detection, bedrock quality and depth measurements, dam structure analysis, and determining the underground water resources.

To test for ionic transmission through moisture present in cement voids or weathered sections of foundation rock, the electrical resistivity method is used for testing concrete and rock material. Low resistivity is typically a sign of the presence of cracks, holes, voids; clay fills, etc. that are prone to water infiltration or leakages in bedrock or concrete foundations (or high conductivity). Contrarily, solid bedrock and concrete foundations free of voids or structural flaws exhibit high resistivity (or low conductivity) due to a lack of moisture. The electrical resistivity of concrete varies from 10 to 100,000 Ωm, depending on the amount and type of fluid present. A resistivity value of less than 50 Ωm typically indicates weak spots in crystalline rocks or concrete foundations.

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