Ground-Penetrating Radar for Dam Investigative Applications

An accurate non-destructive approach can save time and money

CASE STUDY

As the world struggles to improve its critical infrastructure, attention is being paid to *non-destructive testing* (NDT) methods that can help to accurately determine what can be repaired and what needs to be replaced.

Many see the benefits of NDT methods as a way to cut down on the actual work that has to be done, while making sure that condition data is most accurate. Among the available NDT methods, ground-penetrating radar (GPR) is growing in importance, especially for use in geotechnical, environmental, and dam evaluation applications. Increasingly, the public and privately funded dam owners are looking to GPR technology to inspect the dam infrastructure and surrounding areas.

Ground-penetrating radar basics

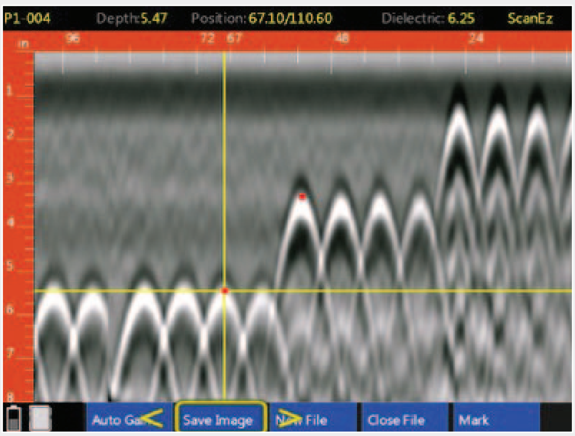
GPR uses radar (radio detection and ranging) to transmit and receive high frequency electromagnetic waves to image the subsurface. A tiny pulse of radio-frequency energy is sent into a material using an antenna. This wave reaches a target and is reflected back to the receiver antenna as a high frequency, electromagnetic reflection. The whole process happens very quickly – at about 100,000 pulses per second. GPR features extremely low power emission rates – less than 1 percent of the radio waves used by a cell phone – so there is no need for extra safety equipment or safety training to use these antennas.

The wave is transmitted into the concrete, soil or subsurface and reflects off different materials with which it interacts. The equipment measures “time of flight,” or the time it takes for the wave to travel through the material, reflecting from an object or boundary, and returning back to the receiver.

Subsurface variations create reflections that are picked up by the system and stored on digital media. An integrated computer records the strength and time corresponding to the return of any reflected signals. These reflections are produced by a variety of materials, including geological structure differences and man-made objects like pipes and foundations. GPR can be used in rock, soil, ice, fresh water, pavements and structures. The reflected signals are used to detect objects, changes in material, and voids and cracks. GPR is considered a most accurate, highest resolution geophysical technology.

In general, GPR works best in dry sandy soils with little salt content; dense clay-based soils are difficult to penetrate with GPR. In some situations, penetration depth may be limited to a few feet or less within clays, whereas targets residing in sandy soils can be detected at depths of 30 feet or more.

GPR equipment makes use of a variety of frequencies (measured in cycles per second), depending upon the depth required and the potential targets being investigated. One cycle per second is 1 Hertz (Hz). GPR is in the megahertz (MHz) or gigahertz (GHz) range. Using a lower frequency will provide a signal that penetrates deeper in the ground but with a coarser resolution. The converse is true for high frequency antennas – greater resolution, but less depth penetration.



This data image example is from a 2.7 GHz frequency antenna showing a series of hyperbola. These hyperbolas correspond to pieces of rebar located at different depths ranging from 1 – 5”.

Using a 400 MHz antenna allows GPR to go up to 8 feet in the ground, so it is best for larger areas for utility locating, archeological remains, and forensics applications. Using a 270MHz antenna penetrates up to 12 feet in the ground but with a less distinct image. With the 200MHz antenna, one can penetrate up to 25 feet, making it a good choice for large storage tanks and shallow geological applications, for example, bedrock or water table layers. *The larger the antennas, the lower the frequency which means the deeper the signal can reach.*