



SUBSURFACE VIEWS

GPR INNOVATIONS HARDWARE AND SOFTWARE

In this issue

- 1
Going Beyond Rebar Locating
- 3
Mystery Solved –
The “Non-Locatable” Pipe Located
- 5
Automating Borehole GPR Surveys
- 6
Upcoming Courses & Tradeshow

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Conquest®100 - Going Beyond Rebar Locating

Since the first generation of Conquest®100 GPR was unveiled in 2001, Conquest®100 has been helping contractors locate embedded objects in concrete. In most cases, professionals are looking for rebar, conduits and post-tension cables to avoid them when cutting or coring concrete. In other scenarios, locating the position, amount and cover depth of rebar is essential for structural analysis. But there are other applications for Conquest®100. The examples below show how Conquest®100 is used to locate voids under a concrete slab, map corrosion of rebar and aid in forensic investigations.

Locating Voids

GPR waves reflect off changes in the dielectric properties of materials, the strength of the reflection being determined by the difference in these properties. When scanning concrete, GPR waves reflect whenever they encounter embedded objects, such as a metal rebar, plastic conduit or even the bottom of a slab. In a slab-on-grade situation, GPR can also be used to locate voids that sometimes form beneath the concrete. Voids under concrete produce a strong reflection, due to the large contrast between the properties of the concrete and the air or water filled void underneath. Knowing

the location of voids is essential, so that they can be injected with grout before they become too big and either the concrete cracks or collapses in that area.

In this example, an engineering company was called into a large factory to investigate locations where the floor was cracking. They decided to use GPR to scan the problem areas. Several line scans were run initially to gain an understanding of how the floor was constructed (Figure 1).

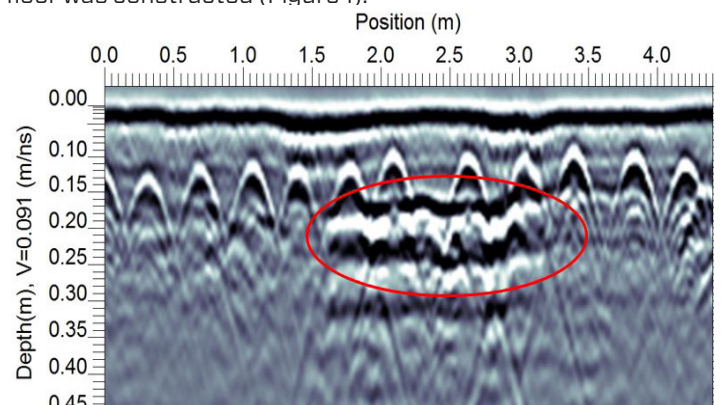


Figure 1: GPR line on slab-on-grade concrete floor reveals a void. The strong contrast between the concrete and air-filled void produces a strong reflection at the bottom of the slab.

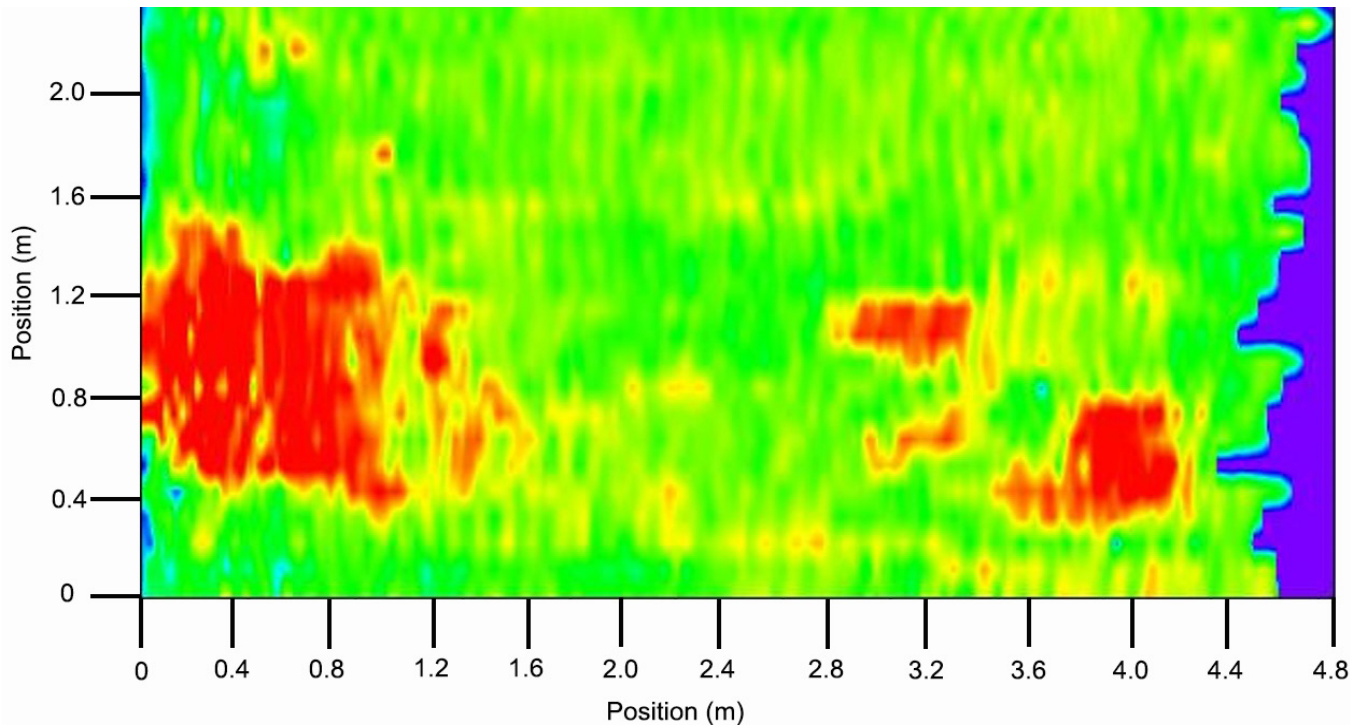


Figure 2: Depth slice at the bottom of the concrete slab shows the lateral extent of the voids in red. The ability to collect large grids with Conquest®100 and combine them in EKKO_Project™ provides quick and easy visualization of large areas, especially useful for void detection.

The concrete had rebar, which are shown as hyperbolas near the top of the image. The interesting part was the strong area of reflection observed below the rebar, between horizontal positions 1.5m and 3.0m. Following the line scan, two large Conquest®100 grids were collected, each measuring 2.4m x 2.4m, to obtain the areal extent of the voids. The grids were subsequently combined in EKKO_Project™ to create an area covering 2.4m x 4.8m. The depth slices generated confirmed what was seen in the line scan by revealing some anomalies at approximately the 15-cm depth mark (Figure 2). These anomalies are shown in red and correspond to areas of higher reflection strength.

These anomalous areas were then drilled and verified to be voids. They were injected with grout to stabilize the slab.

Corrosion

Finding deteriorated concrete relies on the fact that GPR waves are attenuated and scattered by an area of concrete that is deteriorated. For example, intact steel rebar reflects more energy than corroded rebar. Users are trained to look for areas that return a weaker signal as an indicator of deterioration. A deteriorated zone can be caused by water infiltration (even if the corrosion process has not started) or rebar corrosion itself.

Most infrastructure deterioration assessments are done on bridge decks; many GPR transects are collected and rebar reflection amplitudes are analyzed. Using Conquest®, Line Scans up to 50 meters (150 feet) in length can be collected,

and the user can look for anomalous areas in the data. In this example, Conquest®100 was used to collect a 20' line on a section of a concrete bridge deck, with no asphalt overlay (Figure 3).

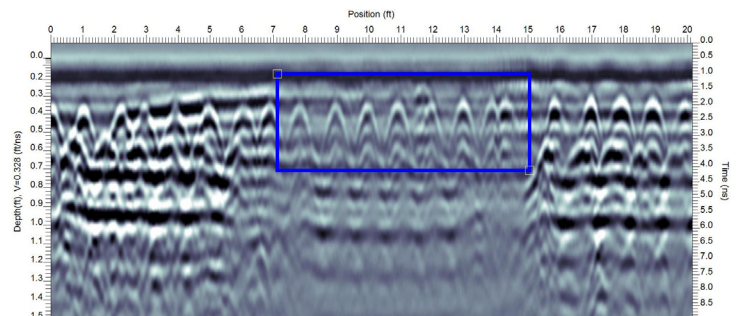


Figure 3: GPR line on a bridge deck shows an area of weaker rebar reflections; a potentially corroded area.

The rebar reflections between the horizontal position of 8' and 15' show a weaker response compared to the surrounding area. It is important to note that one cannot definitively say that those rebars are corroded. Rather, there is an anomalous area that could be caused by water ingress, a repaired area, or corrosion. Either way, it warrants further investigation.

Based on the methodology and processing outlined in ASTM D6087 - Standard Test Method for Evaluating Asphalt-Covered Concrete Bridge Decks Using Ground Penetrating Radar, combining the rebar responses from many lines collected on a bridge deck generates a map showing areas of deterioration (Figure 4).

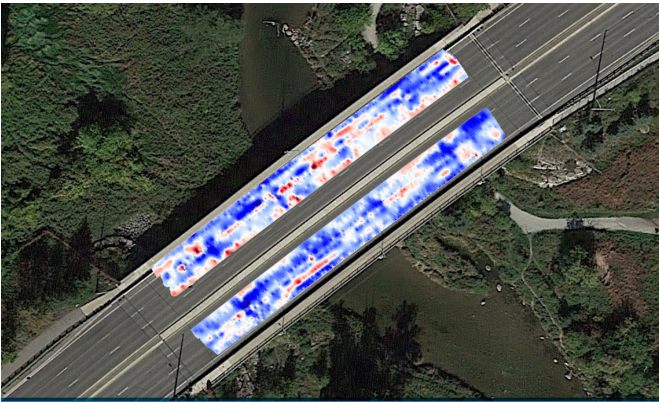


Figure 4: Deterioration index map generated by analyzing the amplitude of rebar responses on a bridge deck. Red areas indicate higher relative deterioration.

Forensic investigation to locate “Escobar’s Millions”

Every so often, Conquest®100 is used for a sensational application! In Colombia, it was believed the drug lord, Pablo Escobar, had hidden millions of dollars throughout his various properties. Two former CIA case officers are now attempting to locate Pablo’s hidden millions. This exciting project was the subject of a documentary series entitled “Finding Escobar’s Millions”, which aired on the Discovery Channel in the US. The investigators enlisted the services of a Calgary-based geophysical consulting company to provide high-tech tools to aid in the search. One of the tools used was Sensors & Software’s Conquest® PCD Enhanced GPR system. At various times, the Conquest® was used to image suspect

areas to determine if there could be a hidden treasure. The Conquest® successfully identified the locations of safes, clearly delineating box-shaped areas for further investigation (Figure 5). In one episode, a 2’x8’ grid was collected, and a noticeable rectangular structure was observed; the investigators were very excited to see what was contained inside this suspect structure. To find out what they discovered, and see how Conquest® was used, tune into the Discovery Channel for full episodes.



Figure 5: While searching for hidden drug money, a Conquest depth slice reveals a cavity behind a wall at a property formerly owned by drug lord Pablo Escobar.

Conclusion

In the above cases, a Conquest® GPR has been employed to locate features or objects that would otherwise be undiscoverable. These examples show the applications for Conquest® are well beyond simply detecting rebar and conduits. The simplicity and ease-of-use of the Conquest® system allow for the quick adoption of GPR technology in varied applications.

Mystery Solved – The “Non-Locatable” Pipe Located

It’s no secret that there is a tremendous amount of infrastructure buried under our feet. Knowing where services are located is an ongoing challenge given the rapid rate at which installations are taking place.

Ground Penetrating Radar (GPR) is a proven, cost-effective solution to help locate buried utilities. GPR excels at locating not only metallic but also non-metallic utilities that cannot be found using traditional electromagnetic (EM) methods; these utilities are often referred to as “non-locatables.”

For years a building manager at a company headquarters in Germany had known that a water pipe was running into their facility but had not been able to locate its exact whereabouts.



Figure 1: When utilities cannot be located through traditional means, locating professionals bring in the LMX200™ to get the job done.

Locators using traditional EM technology tracked the pipe to a certain point where it then appeared to end abruptly. A valve had reportedly been installed to allow for the pipe to be drained; however, none of the locators could find it. They concluded that the original contractor had switched from metal pipe to PVC pipe during the installation. Since EM technology relies on objects being metal to trace them, the PVC section of pipe was not locatable. The building manager recognized that it was a maintenance concern and made one final effort to locate the pipe and valve by calling in a GPR expert.

The contractor used an LMX200™ GPR system for this project. As the operators were surveying the area with the GPR (Figure 1), they encountered several different utilities, each appearing as the classic hyperbolic-shaped GPR response. To ensure they were indeed tracking the water pipe, they moved to the area where the pipe was found using EM methods and crossed it using GPR. On the screen, they noted the depth of the pipe and how the hyperbola appeared in the GPR data. They proceeded to search the area, focusing on responses at that approximate depth, and for hyperbolas that looked similar.

Data was collected in a zig-zag pattern crossing over the buried pipe (Figure 2), with lines about 1 meter apart. As the pipe was identified in the data, the locations were marked on the ground using flags. The path of the pipe was determined by “connecting these dots.”

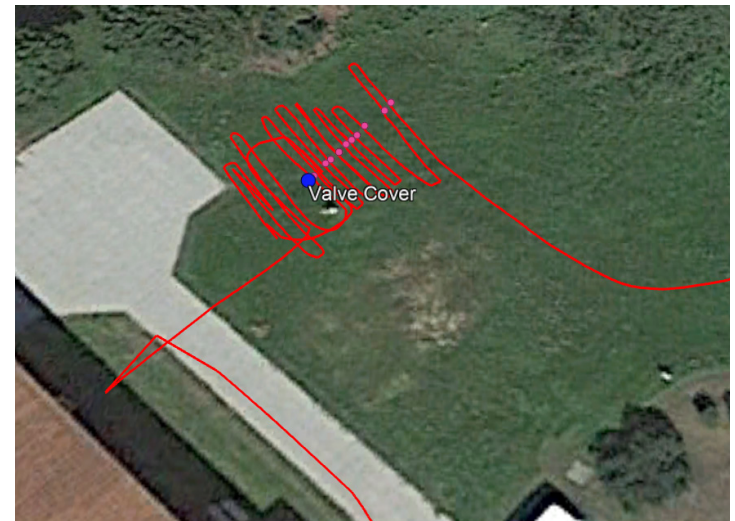


Figure 2: Survey path of the GPR as it crossed the pipe.

The Line Scan data is shown in Figure 3. Each image is a traverse crossing the pipe at 90 degrees.

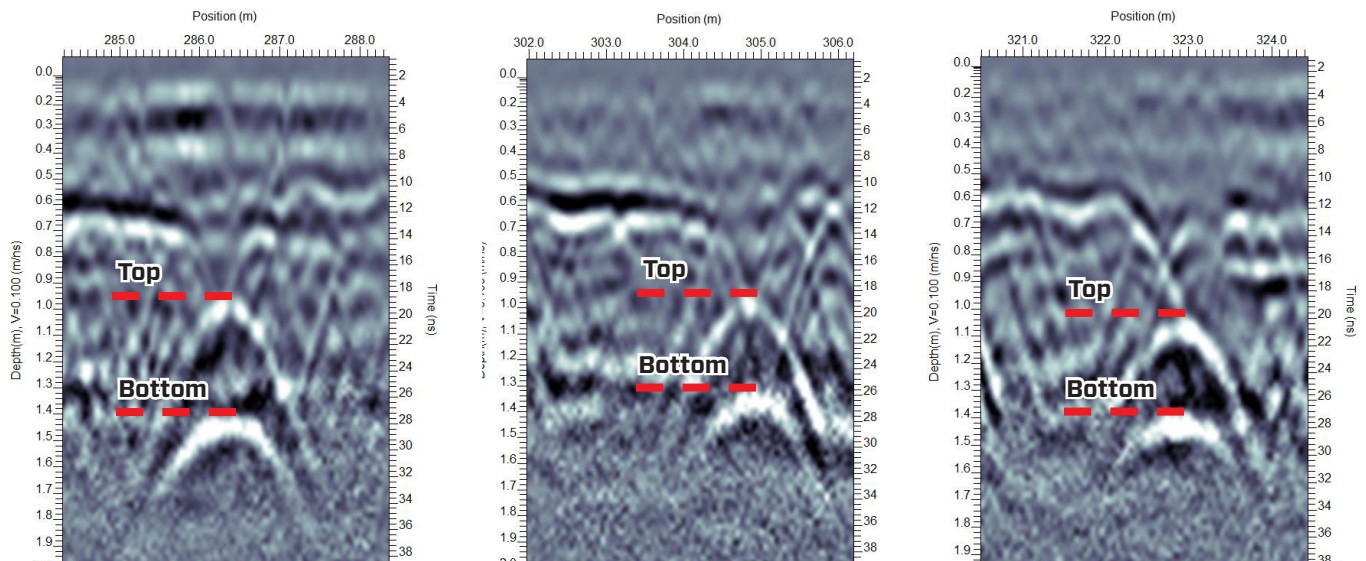


Figure 3: Each crossing of the pipe shows two hyperbolic responses, aligned vertically. This indicates the pipe is non-metallic.

There are some features worth noting in the data:

- The pipe is at approximately 1m (3.2') deep.
- There are two hyperbolas, one above the other. The top hyperbola is caused by the GPR reflection from the top of the plastic pipe; the lower one is from the bottom of the plastic pipe. (Note that the bottom of the pipe is clearly visible because the pipe is non-metallic and water-filled creating a distinct pipe bottom response)

After tracking the pipe with the GPR, the LMX200™ arrived at the valve and identified exactly where they needed to excavate.

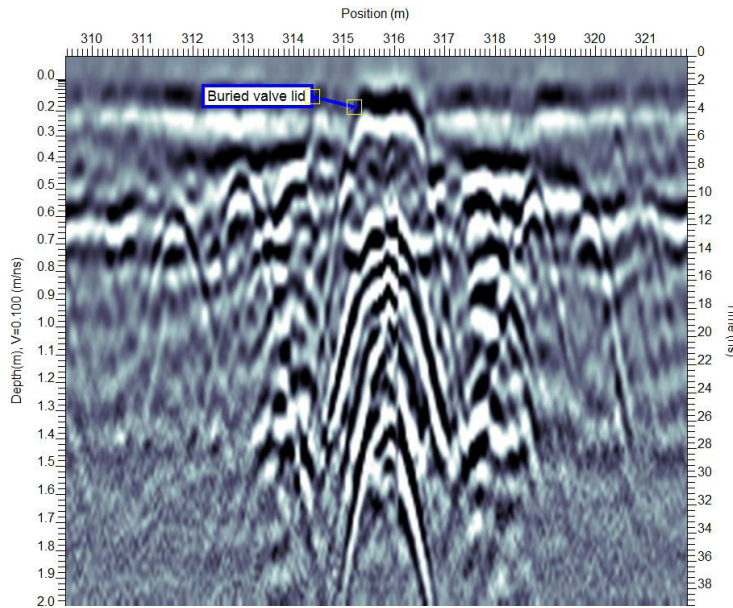


Figure 4: The LMX200™ located the buried water valve, which was subsequently uncovered to drain the pipe.

GPR was able to successfully locate and map the entire path of the water pipe, both the metallic and the PVC sections, right to the buried water valve lid, enabling them to drain the water pipe (Figure 4).

The building manager was pleased to have located the route of the pipe and the position of the valve. The LMX200™ provided valuable information to allow for scheduled maintenance on the pipe and to ensure this pipe is avoided during future upgrades to the facility.

Automating Borehole GPR Surveys

Sensors & Software has developed a borehole winch to provide rapid acquisition of zero-offset profiles and multi-offset gathers when using the pulseEKKO® borehole system. The motor-driven winch provides automated positioning through a distance encoder which also triggers data acquisition at fixed depth intervals, making borehole data collection more accurate and significantly less time-consuming. Operators can vary the winch speed depending on the borehole conditions. This results in faster generation of tomographic images of the subsurface.

A common area of interest is using borehole GPR to augment security, for example, conducting surveys to detect clandestine tunnels at sites important for national security or at international border crossings. One issue preventing widespread use of GPR technology for this application is that data acquisition is neither simple nor routine. The new motor-driven winch system simplifies and speeds up borehole data collection, making use of GPR for this application more practical.



Figure 1: Motor-driven borehole winch with depth encoder.

One survey method for borehole data collection is Zero Offset Profile (ZOP) where data is collected by simultaneously moving both the transmitting and receiving antennas up the boreholes at the same speed. This survey provides an indication of any anomalies that are present between the boreholes. Figure 2 shows an example of ZOP data where the travel time is significantly shorter from 2 to 4 meters in depth compared to other depths. This is indicative of an air-filled zone between the two boreholes.

Another survey method is the multi-offset gather (MOG) where the transmitting antenna is fixed, and the receiving antenna is moved in the borehole. Figure 3 shows a tomographic velocity image of an air-filled tunnel between boreholes, generated by processing multi-offset gathers (MOGs).

The introduction of the automated winch system for pulseEKKO® borehole systems increases the accuracy and reduces the time required for borehole surveys, enabling this technology to be adopted into additional application areas.

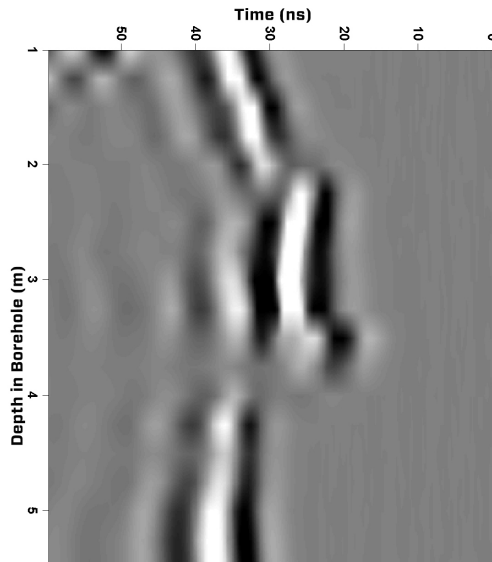


Figure 2: Raw data from a Zero Offset Profile (ZOP) showing an air-filled zone between the boreholes from 2 to 4 meters in depth.

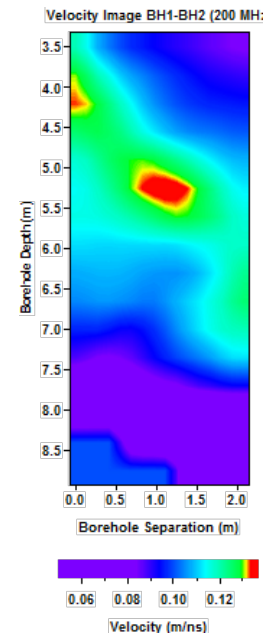


Figure 3: Tomographic velocity image of an air-filled tunnel between boreholes, generated by processing multi-offset gathers (MOGs).

Upcoming Courses

[Webinar: GPR Question & Answer session](#) - February 14, 2018. Register at sensoft.ca/training-events/

[Subsurface Imaging with GPR course](#) - March 5, 2018. Mississauga, ON, Canada

[Concrete Scanning with GPR course](#) - March 6, 2018. Mississauga, ON, Canada

[Webinar: EKKO_Project™ - Interpretation Module](#) - March 21, 2018. Register at sensoft.ca/training-events/

Upcoming Tradeshows

[World of Concrete \(WOC\)](#)

January 23-26, 2018, Las Vegas Convention Center, Las Vegas Nevada, USA

[CGA 811 Excavation Safety Conference & Expo \(CGA\)](#)

March 6-8, 2018, Phoenix Convention Center, Phoenix, AZ, USA

[SAGEEP](#)

March 25-29, 2018, Nashville Marriot Airport, Nashville, Tennessee, USA

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