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Subsurface Views

GPR Innovations: Hardware and Software

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Sensors & Software

Advantages of Integrating GPR in Concrete Inspection

Today, more than ever, owners and managers of real estate are driven to build and renovate their properties to be among the most attractive in order to net the largest possible return on their investment. Price-Waterhouse-Coopers recently released a report that predicts 2015 will be a year of active buying, developing and rehabbing of commercial space in most North American markets.

Tremendous growth in tenant expectations for building performance, both in commercial and residential markets, has resulted in building structures becoming more complex. To accommodate the variety of embedded services, the number of conduits built into concrete slabs and structures is increasing, often to the point where structural engineers have concerns about where they are going to place their concrete. Post-construction additions require routing of conduits or piping through crowded slabs, and must be done without damage to existing embedded services or primary structural components. Contractors face this while still addressing demands for higher productivity, workplace risk/hazard management, liability mitigation and seamless integration into the workflow of the rest of the project.

All this has created a growing demand for services such as concrete scanning, non-destructive testing (NDT), cutting and coring. Professionals and companies need more sophisticated tools and processes to help assess, build-in, or add these embedded elements into the concrete. Providers of concrete scanning, testing, cutting and coring services also need to offer value and efficiency to be competitive and successful in getting contracts.

Amongst the non-destructive technologies for imaging and assessing the interior of concrete structures, ground penetrating radar (GPR) has emerged in recent years as a leading tool. Unlike traditional X-raying, GPR is safe, requires access to only one side of a slab or wall, usually involves only one technician (without expensive certification associated with nuclear/x-ray sources), can produce results in real time and can be performed during normal business hours with minimal disruption to building operations.

There are numerous advantages and benefits in scanning concrete with GPR:

Accurate Imaging: GPR provides accurate images and, the ability to analyze slices at varying depths, provides the depth and orientation of embedded objects. Dual-technology systems, such as the Conquest 100, that combine GPR and Power Cable Detection systems, go a step further and indicate which conduits hold hazardous current carrying power lines.

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Workflow for Concrete Scanning

During our training courses, we get many questions from new users about the practical side of concrete scanning. Learning to operate the equipment is fairly straight-forward and users improve their interpretation skills the more they use it. But to really be successful as a service company, it's important to follow a suitable workflow that ensures you are delivering results that meet customer expectations, on-time and without incident. This article discusses a typical workflow that should be followed, with a focus on the concrete inspection market. However, some concepts can apply to other industries as well (for example utility locating, and forensics).

Before even leaving the office, it's important to ask the customer the right questions to determine if GPR is even feasible for the job. Sometimes people have incorrect, perhaps exaggerated, information about GPR's capabilities. If expectations are not realistic and achievable, this not only gives GPR a bad name, but is also a waste of everyone's time. Find out what are they trying to accomplish. Are they looking to core, trench cut, verify placement/depth or other investigative information? Some specific questions to ask:

1. What is the problem/ target feature being investigated?
2. What is the target depth? Note that maximum GPR penetration in concrete is about 24" (60 cm)!
3. How old is the concrete? (new concrete can take up to 2 months to cure from a GPR point of view)
4. Are there any obstructions or unique site conditions?
   Related to this, is there adequate room to move the GPR scanner?

Once you have determined that GPR is suitable, the next step is to properly estimate the job. The site should be ready and clear when you arrive otherwise you are wasting time doing on-site preparation. If the job is the typical "scan before you core", then you probably already have a set charge for that (per grid or per hour). If not, you will want to get as much information as possible and request as-built drawings. Address the liability issue; should an accident occur, liability is always a concern and while GPR is very accurate, there is no technology that is 100%. Many companies choose to have terms and conditions in their work order form to mitigate that. Without sounding negative, it's important that customers are clear that they are not buying insurance that will protect them from liability.

Upon arrival at the job site, take some time to look around, especially beneath a suspended slab or behind a wall. Take note of the visible construction design (beams, pan decking, surface mounted conduits underneath). Also try and talk to the project engineer or General Contractor to find out about any non-visible construction details (post-tension deck, hollow-core slab, topping slab). Knowing construction practice/layout will greatly aid during data interpretation. Also very important is to get an idea of what features may be embedded in the slab. If this is a coring job, you obviously don't want to hit gas/electric as these can be very dangerous. Cutting telecom/network cables, while not fatal, can be financially disastrous for a company's downtime. If there are any indications that these may be in the slab, you should be extra vigilant when analyzing the data.

Following a workflow does not mean there is a set formula for every job, but it provides a guideline. You still need to tailor how you approach the job to meet the customer's requirements. As well, you have to be flexible on-site and adjust your scans should you find something unexpected. Companies need to be well versed in approaching the job in its entirety, not just from an equipment operation point of view. The importance of communication in understanding the customer's needs and what exactly you are going to deliver can never be overstated. ■

Advantages of Integrating GPR in Concrete Inspection

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Effective In Order To Be Efficient: Even as the need for these services increases, the dollars available to pay for them are hard to find. Having the ability and reputation for doing a thorough job without repeated visits or errors is a real competitive advantage. Speed is good, effectiveness is better. Professional-grade GPR tools are able to provide this advantage. Providers should match their effort to site conditions, performing reconnaissance scans to decide where and if a fuller scan is required.

Workflow Integration: Service providers must fit seamlessly into the workflow and project management of their customers, especially on large projects. In fact, they can gain competitive advantage by offering ways to cut out time and money from the processes of larger projects. For example, real-time assessment by off-site reviewers of scanned results can reduce the time between scanning and cutting, often avoiding the need for a second site visit.

Non-Invasive: Assessment and testing without expensive and harmful destructive testing is always preferable. Even where expensive destructive testing or coring is required, targeting it to where it is most effective can save time and money.

Difficult Sites: GPR sensors are small and can be used in tight spaces and in any orientation on floors, walls and ceilings. Critically, GPR is applied from the exposed surface and is able to find features in slab-on-grade. It can even identify voids in the surrounding materials. Large areas can be mapped efficiently by deploying the GPR sensor on a cart or vehicle-towed platform.

Flexibility: GPR can be thought of as many tools in one, and offers owners the possibility of breaking into new businesses and activities. From marking ahead of cutting or coring, to investigating structural components, providing due-diligence records, to assessing the deterioration of rebar, a good GPR system can do it all.

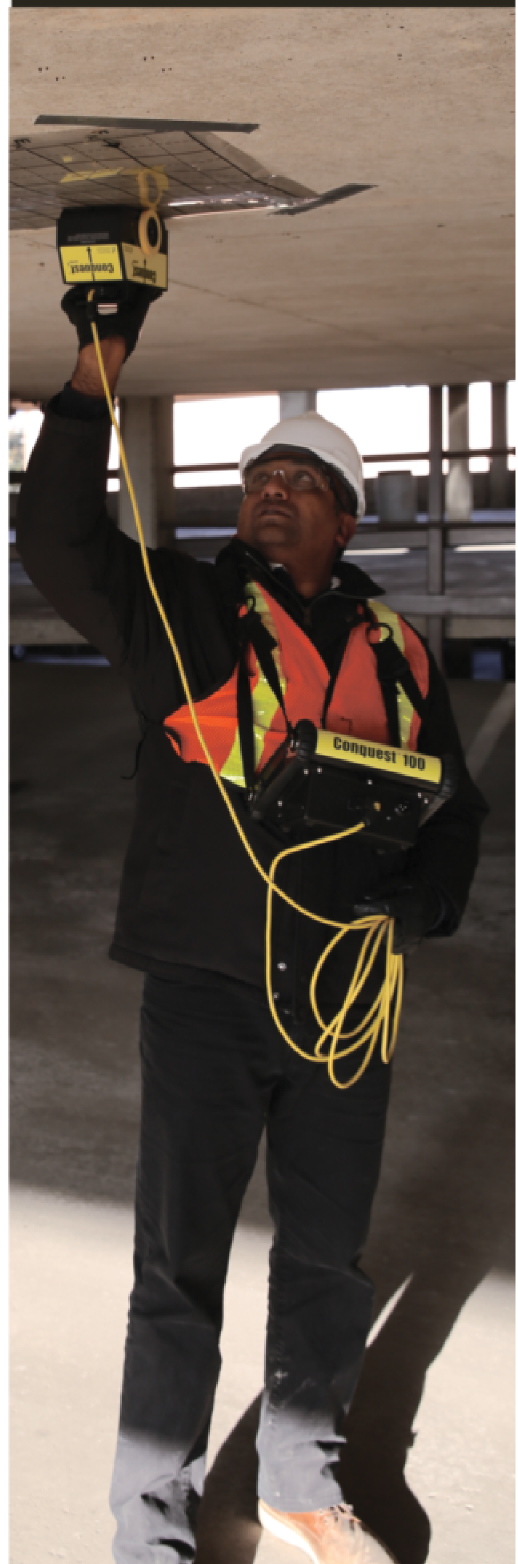
Health and Safety: There are significant regulatory, financial and social reasons for being concerned about workplace safety, and GPR is the most effective technology to address these concerns. Not only is GPR harmless to the infrastructure, it also poses no risk to the operators or the general public. You can safely use GPR in a crowded public setting without any risk to the people around.

Ownership: Modern GPR systems are inexpensive and easy to use, requiring very little training and no certification costs. Improved data processing has automated much of the process, including automated reports where needed. Owners can also benefit from detailed usage records provided by leading GPR systems, knowing when the system was used, where it was and what is was used for.

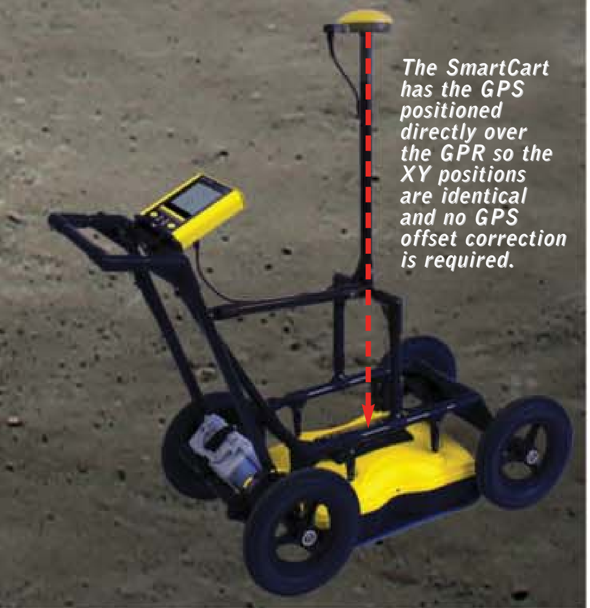
Concrete scanning GPR products have been around for a number of years, but their use was limited due to the need for experienced technicians and challenges in data interpretation. Sensors & Software transformed a complex and expensive technology into solutions that are easy-to-use and affordable. Developments in both hardware and software, including sensors to detect the magnetic fields associated with current carrying electric cables, refinement in user interfaces and coupling GPR with other complementary technologies have combined to make the use of GPR an economical, reliable and widely accepted method for locating objects and services embedded in concrete.

Recent iterations of this technology transform data into 3D volume images which can be displayed as volume renderings or as plan maps at specified depths. Presenting these images with corollary data in engineering reports document due diligence. The ability to quickly generate and share these images can be a significant competitive advantage.

Conquest 100, launching in February 2015, takes this philosophy to new heights with better functionality, ease-of-use, and integration into the 21st century workflow. GPR technology has emerged to become a valuable and reliable tool to improve asset protection and risk management as well as a significant profit center for service providers. ■



TIPS: Positioning GPR Surveys - GPS Offset



The SmartCart has the GPS positioned directly over the GPR so the XY positions are identical and no GPS offset correction is required.

The GPS positions of every GPR system in a 6-channel SPIDAR can be corrected if the offset between each GPR and the common GPS is known.

Google Earth plot showing the paths of each GPR system in SPIDAR configuration after the GPS offset correction is applied.

Many GPR surveys are done in Locate & Mark mode, meaning the operator monitors the data display and interprets the data in real time. When features of interest are found, their location is determined using the back-up arrow and the position is marked with a flag, paint or immediate excavation occurs.

Other surveys are done in Survey & Map mode. In this type of data collection, typically a large area needs to be surveyed, and productivity is important. Data is collected with a single channel or, for even higher productivity, a multi-channel system like a SPIDAR system is used to cover a wider swath in each pass. The large data volume from such surveys means that real time interpretation is difficult or impossible and, in most cases data are often collected without the operator even looking at the data display. Data are interpreted during post-survey analysis of the data using the EKKO_Project software for cross sections and depth slices or 3D for grids. Post-acquisition processing and interpretation become essential when addressing complex sites with a variety of ancillary data. Other survey data, remote sensing images, and construction records must often be referenced to place the GPR data in context.

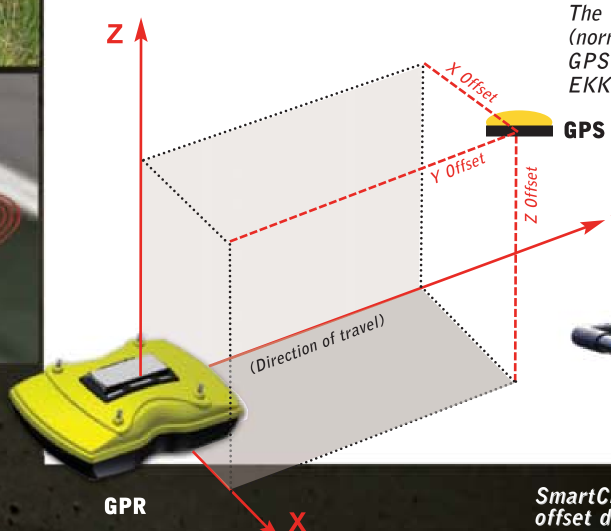
When a feature of interest is found in the GPR data, its physical location must be determined. In the early days and even now in some situations, positioning is often established using site-specific local grids and surveyed-in marker positions. Nowadays it has become quite commonplace to collect GPR with GPS to provide geo-referenced positioning for the GPR survey lines and grids.

SmartCart GPS mounts are designed so the GPS receiver sits directly above the GPR system so the data from each system is coincident. In other deployment configurations like low frequency bi-static, SmartChariot or SmartTow, it may not be possible or convenient to have the GPS directly over the GPR system. Providing the GPS is positioned at a defined XYZ offset from the GPR data reference point (normally at the mid-point between the GPR antennas), the EKKO_Project* software provides the tools to correct the GPS position of the GPR data.

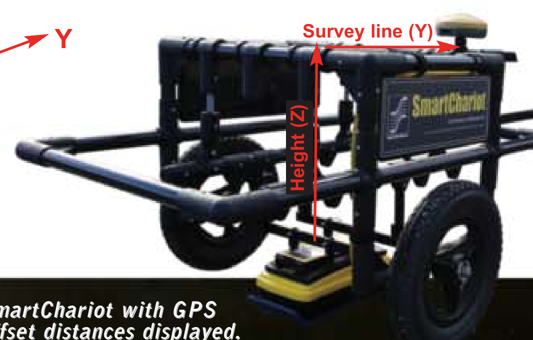
For example, this feature corrects the GPR positions of data collected with the SmartChariot; the GPS mount is +0.5 meters ahead of the GPR in the Y position and +0.5 meters above in the Z position.

An extension of this capability is to use a common GPS for the positioning of each GPR sensor in multi-channel SPIDAR system, provided the local XYZ offset of each GPR sensor is recorded.

** In order to apply this correction, EKKO_Project requires two pieces of information: the XYZ offset from the GPR antenna to the GPS antenna, and the orientation of the system for each point along the line. The XYZ position offset is provided by the user at time of data import. The system orientation is automatically computed using a set of advanced filters to recreate the path taken by the GPS antenna and determine which way the system was pointed.* ■



The XYZ distances from the GPR reference point (normally the mid-point between the antennas) to the GPS are required for the GPS Offset correction in EKKO_Project.



SmartChariot with GPS offset distances displayed.