Ground-Penetrating Radar

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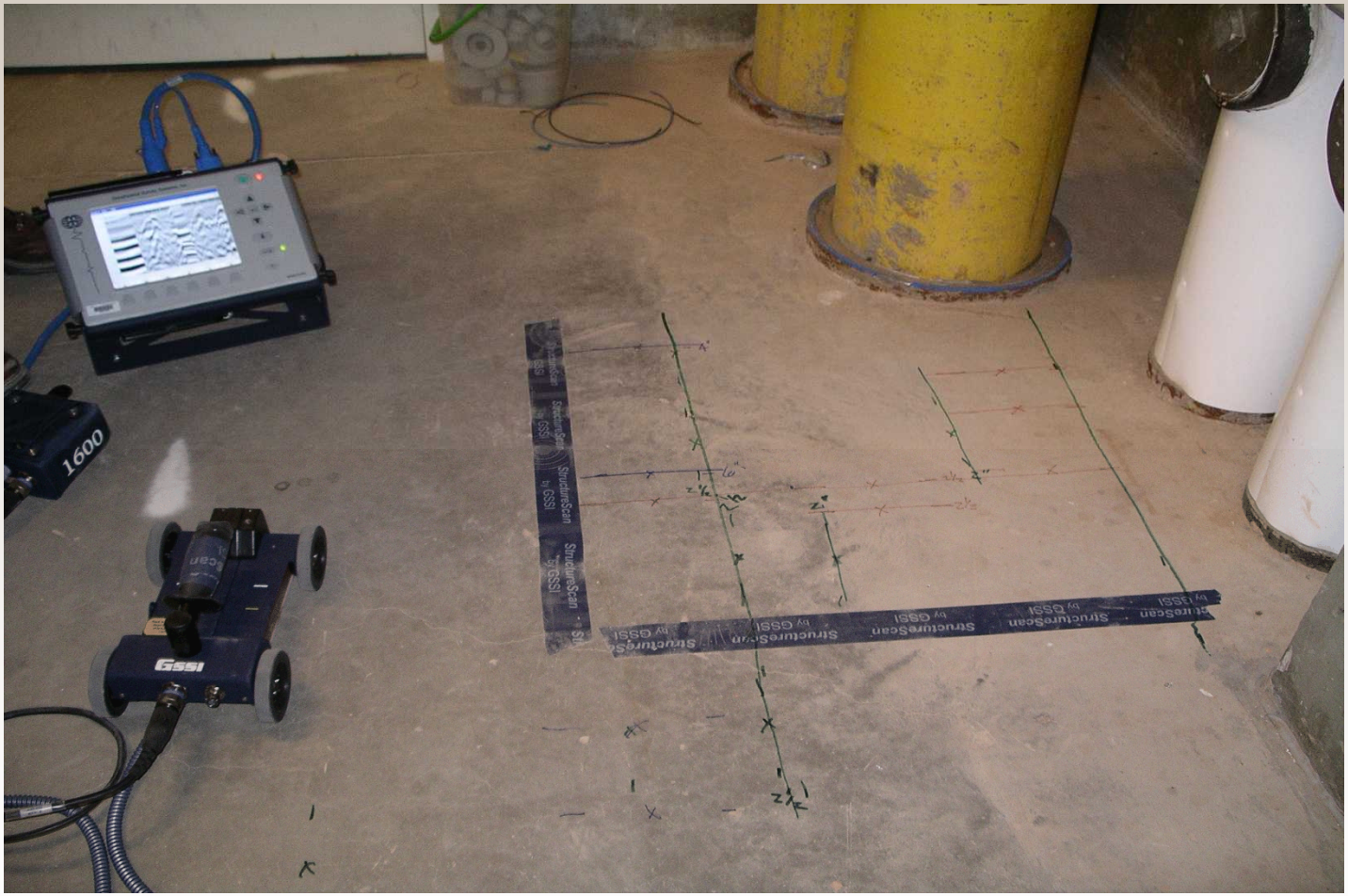
Ground-Penetrating Radar Structure Scan Optical



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What is GPR?

- GPR stands for Ground-Penetration RADAR (RAdio Detection And Ranging)
- High-frequency electromagnetic (EM) reflection
- At 1.6 and 2.6 GHz, it is in the microwave range
- Very low-power emissions; 1% of a cell phone
- Ultra-wide band (UWB) energy - uses a wide range of frequencies
- GPR provides a real-time, interpretable cross-sectional view of the subsurface

Uses for GPR

- Concrete inspection – locate metallic and nonmetallic targets in walls and floors
- Structure inspection – slabs, walls, balconies, decks, and columns
- Condition assessment – map relative concrete condition for rehab planning
- Ceiling inspection
- Measure slab thickness
- Void detection

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Why Use GPR?

- Unlike X-Ray, radiography, or other techniques, GPR is real-time.
- GPR can significantly increase the safety of penetrations into concrete and walls or similar materials.
- Adding GPR to your existing procedures enhances the planning and decision making prior to performing a penetration.
- Perform penetrations without costly rebar hits and damage caused by cutting through structurally significant reinforcement.
- Other inspection tools only detect metallic objects or the presence of a magnetic field induced by flowing current.
  - GPR Detects metallic and nonmetallic elements
- Can you afford not to?

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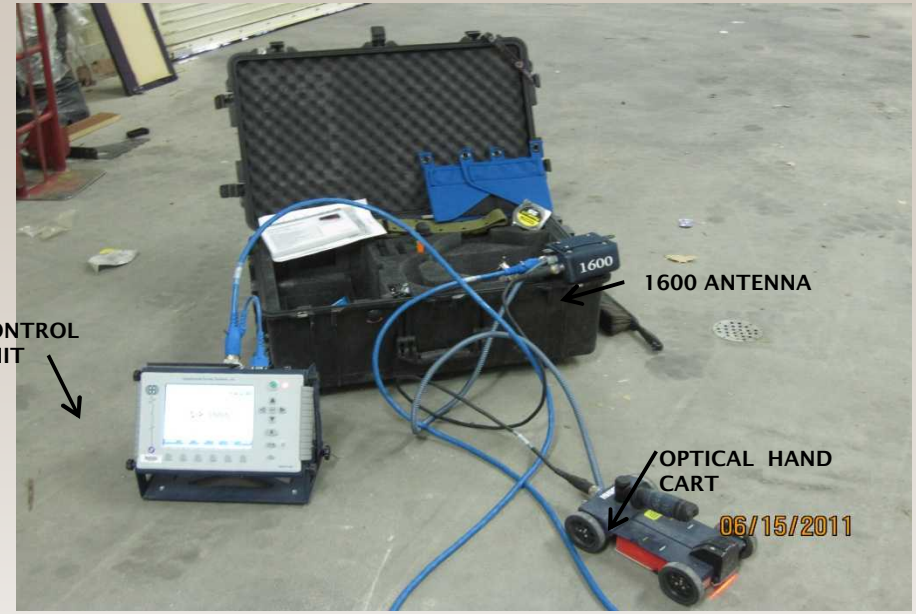
Equipment Information



- Geophysical Survey Systems, Inc. (GSSI) Model 5100B with a 1600MHz antenna, capable of scanning to a depth of 18" (Depending on type of concrete) Cost: $29,000
- Locates rebar, tension cables, and conduits (PVC and metal). **Cannot determine whether targets are electrical or have an electrical charge.**
- No site hazards or need to close off work areas as with radiography (X-Ray)
- Capable of scanning objects in 3D

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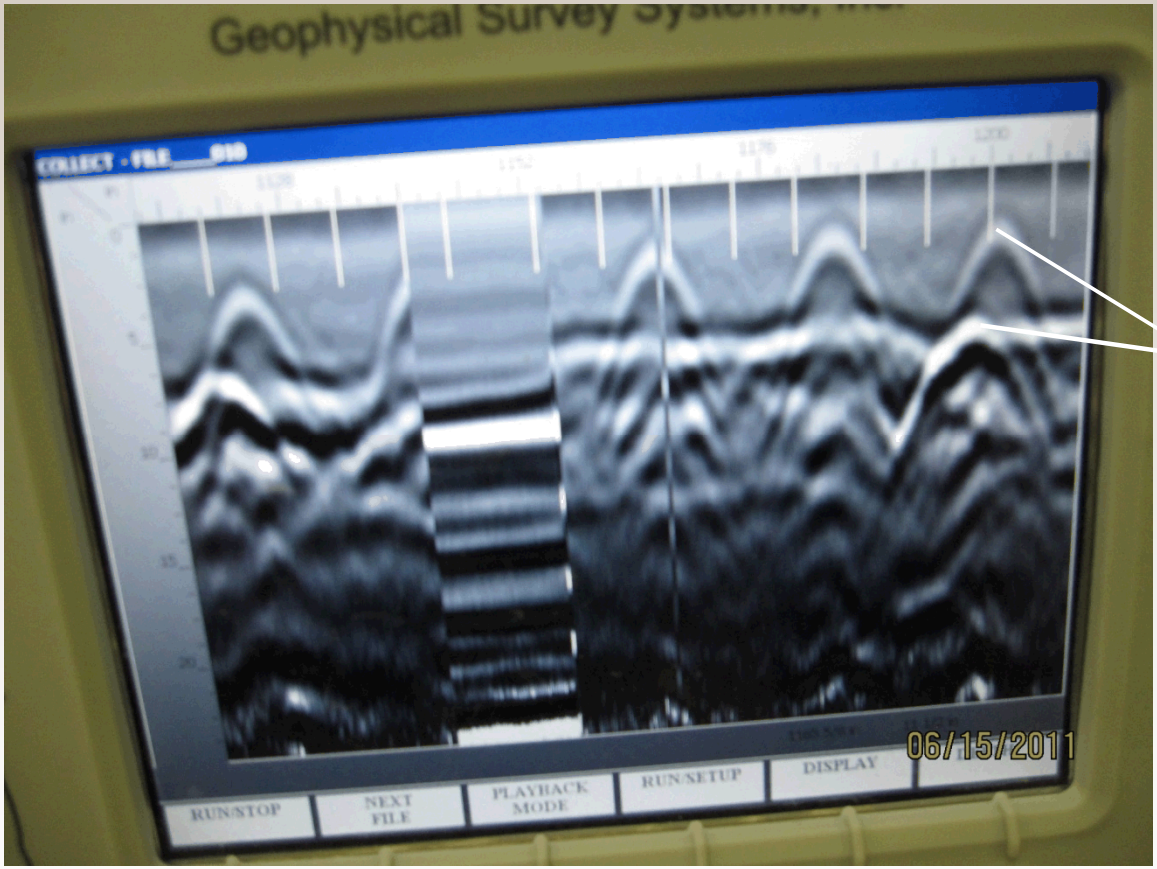
Anatomy of a GPR Profile



Tops of objects

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Other Equipment Options

- Geophysical Survey Systems, Structure Scan Mini - all-in-one GPR system for concrete inspection
- MALÅ GPR CX (Concrete Imaging)
- Geophysical Survey Systems, Inc. RADAN® 7 software for processing GPR data
- GPR Slice – Software
- Other vendors

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Overview of the GPR Process

- Set up a grid of the Penetration Area.
- Collect data over the grid with the GPR equipment.
- Interpret and mark the findings real time, or record, view, and interpret data on the screen.
- Mark all potential targets in the vicinity of the grid location.
- Review findings with the Facilities Engineer and Contractor.
- Assess the associated risks.
- Determine whether the penetration requires an electrical or other energized system outage.
- Plan the location of the penetration (the area free of any anomalies or identified targets).
- Perform the work with all the proper personal protective equipment (PPE requirements are job-specific and based on potential hazards).

GPR Disadvantages

- The equipment cannot be utilized in tight spaces.
- The technology may miss stacked targets.
- Water acts as a reflector and minimizes the effectiveness of GPR. Wet or uncured concrete may make targets difficult to detect.
- Target locations are typically accurate to a depth of 18 inches, depending upon equipment and conditions.
- Some materials readily absorb EM energy and reduce the effectiveness of the GPR.
- The equipment requires an experienced operator/technician to be utilized effectively.

Test Block

Test block built for testing and calibrating equipment.

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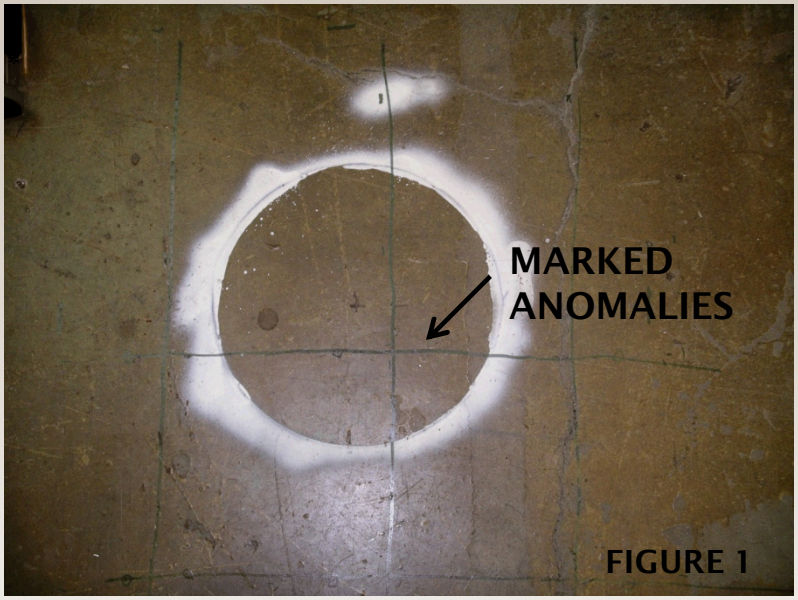
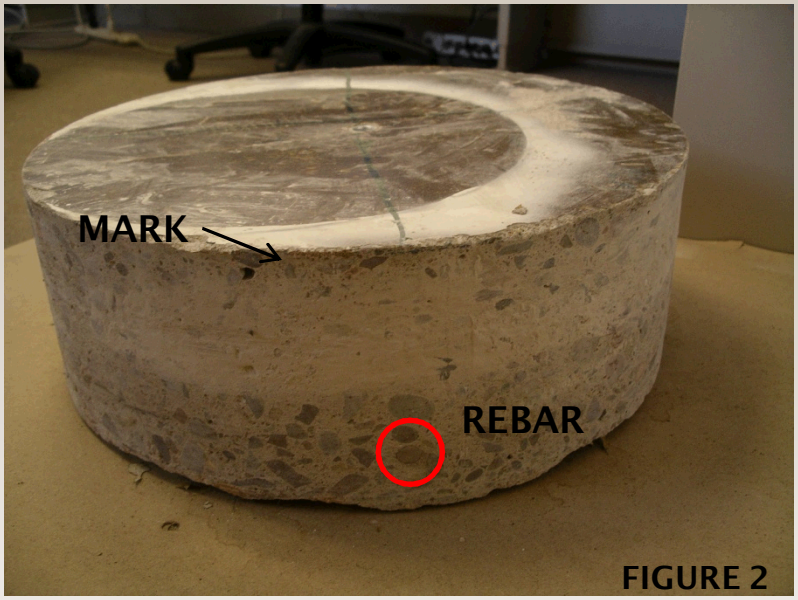
Scan Example 1





- Scope of work was to core drill 12” hole in slab.
- Area was also scanned by electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- All anomalies located during the scan were marked with a green marker.
- Core shown in Figure 2 was kept to verify marked anomalies.

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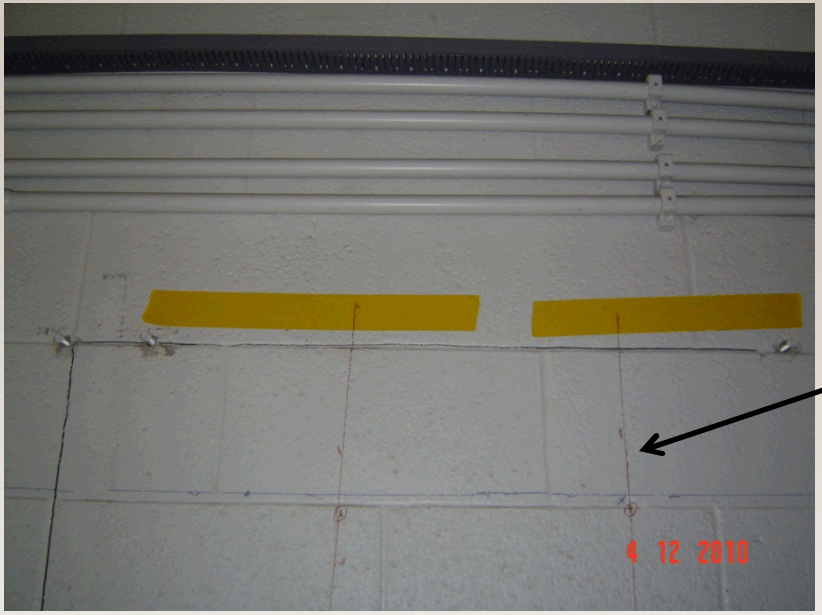
Scan Example 2



- Scope of work was to break down a section of the CMU wall to install a door.
- Area was also scanned by electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- All anomalies located during the scan were marked with blue and red markers.
  - Different colored markings help the technician distinguish direction and depth of different objects.

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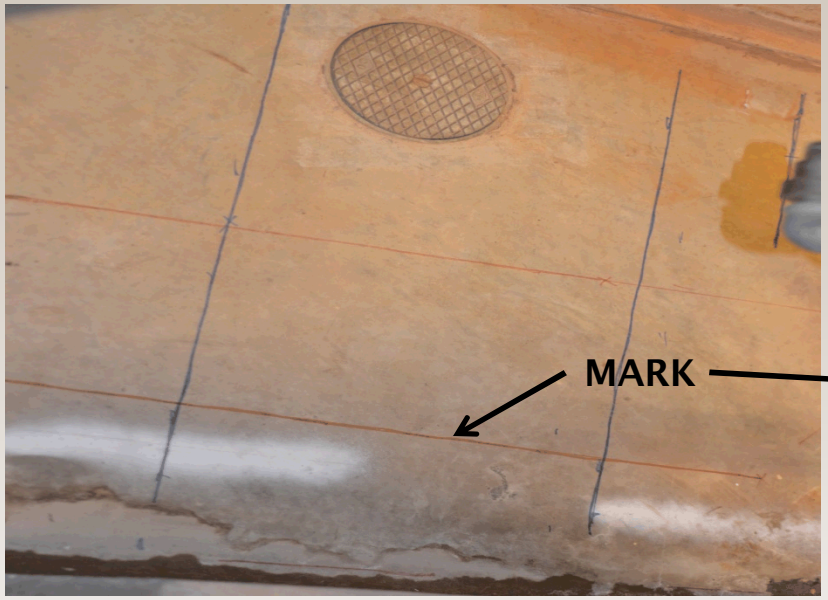
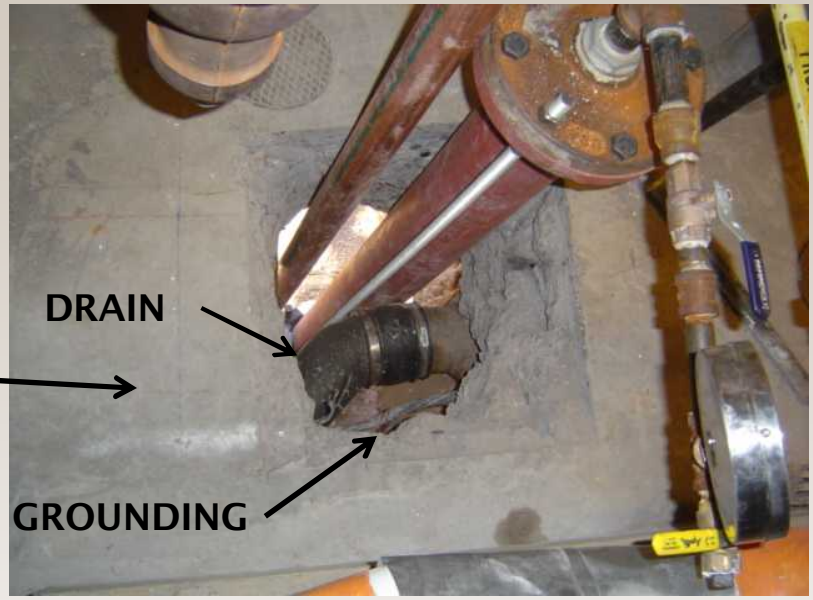
Scan Example 3





- Scope of work was to saw cut 24” x 24” through the floor to tie in water.
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- The scan accurately located all anomalies except the drain, probably because of a setting that only allowed scan at 12” maximum.

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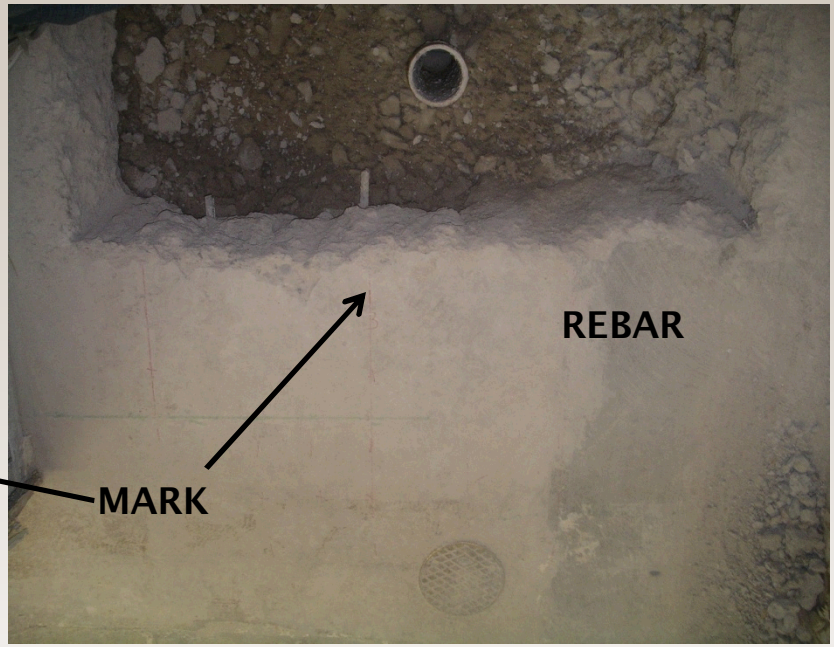
Scan Example 4



- Scope of work was to saw cut floor to expose shower drain.
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- Scan accurately located all anomalies.

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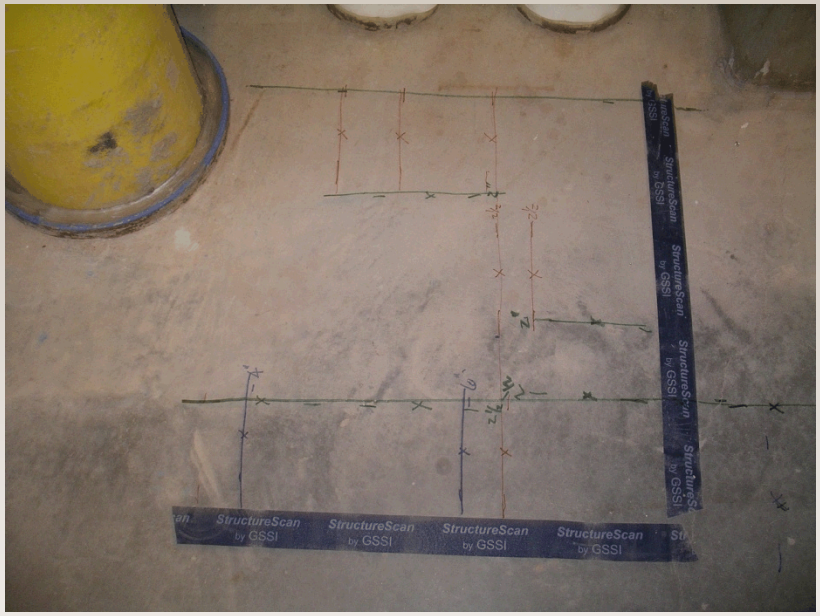
Scan Example 5



- Scope of work was to core drill 6” hole through the slab.
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- Anomalies located during the scan were marked with green, red, and blue markers.
- Core drill location was determined after the scan to avoid marked anomalies and was performed with no electrical outage.

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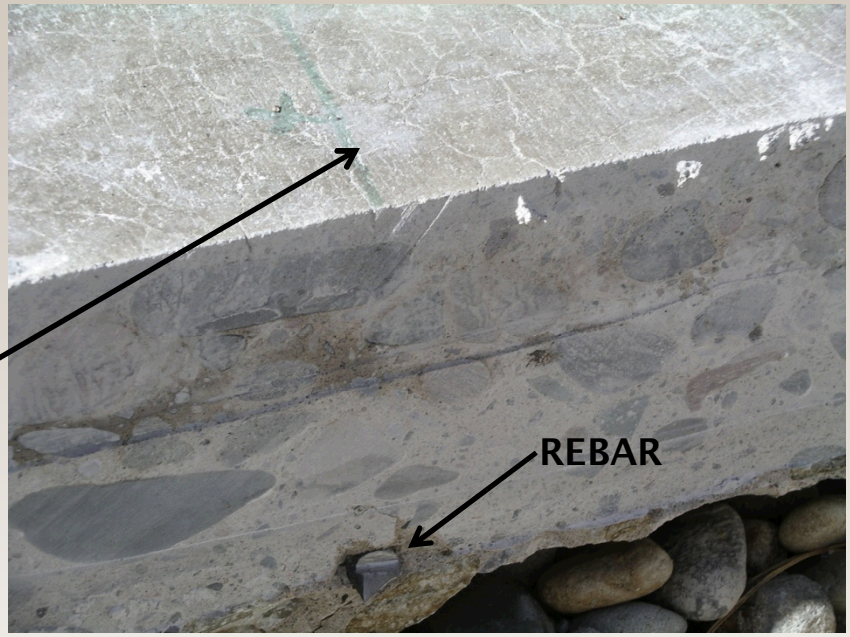
Scan Example 6



- Scope of work was to remove and replace the entire slab in the garage.
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- Anomalies located during the scan were marked with green and red markers.

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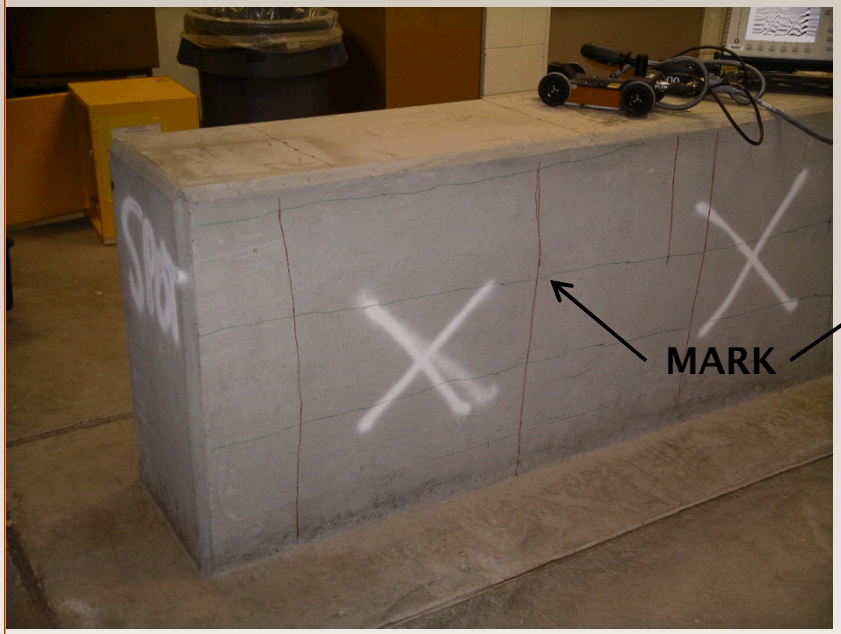
Scan Example 7



- Scope of work was to saw cut and remove concrete bench (13'x18"x33").
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- Anomalies located during the scan were marked with green and red markers.

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Scan Example 8

- Scope of work was to saw cut and remove concrete slab.
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- Anomalies located during the scan were marked with red and black markers.
- An object that resembled a duct was marked near the column.

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Scan Example 9

- Scope of work was to saw cut and remove concrete slab (6'x3'x10").
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- Anomalies located during the scan were marked with red and black markers.
- The other objects marked were not exposed because they were deeper than the 4" cut and removed.

Scan Example 10

- These photos illustrate two different beams scanned for a job.
- Scope of work was to roto-hammer anchors onto structural members without hitting rebar.
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- Anomalies located during the scan were marked with a black marker.

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Scan Example 11

- Scope of work was to core drill through slab for waste lines and floor drains in restrooms, approximately 14 holes of various sizes.
- Area was also scanned by an electrical spotter using a rigid spotting tool; no electrical utilities were detected.
- Anomalies located during the scan were marked with a green marker.
- Contractor could not relocate the core drill above for the sanitary line, so continued with the task and drilled through marks, which turned out to be a conduit.

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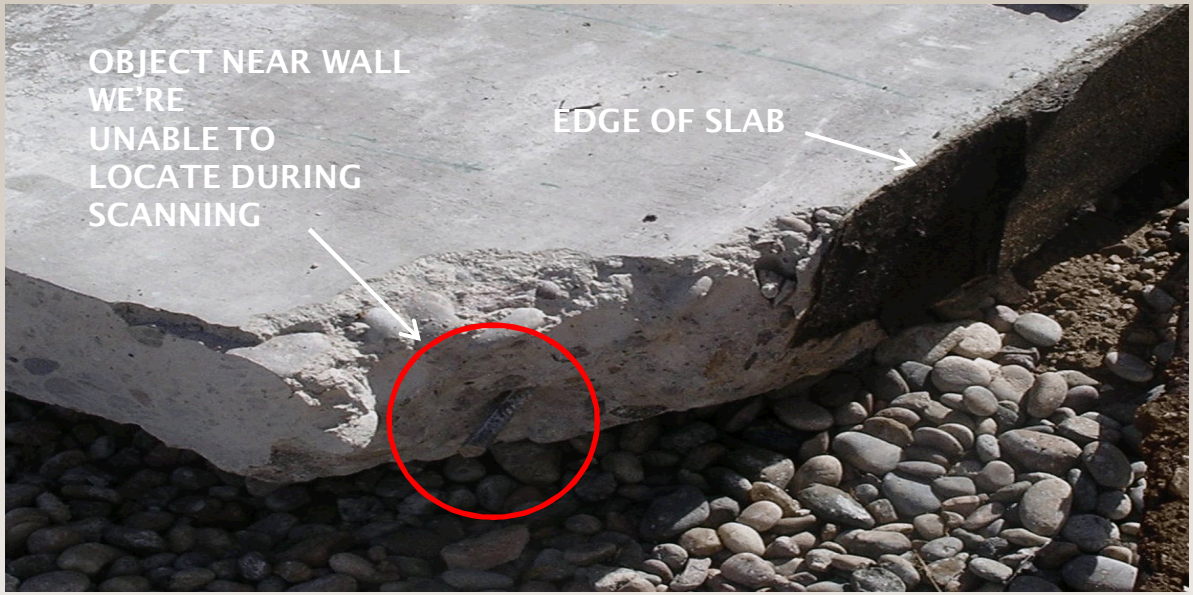
Errors and Lessons Learned



- Rebar along the wall was missed and not marked during the scan.
- The optical hand cart prevents scanning any areas smaller than 2'x2' and up to 6" away from any wall or corner because of the location of the sensor.
- A 2000 MHz palm antenna available from Geophysical Survey Systems, Inc. (GSSI) offers users the ability to reach tightly spaced areas that are inaccessible to the 1600. The palm antenna costs around $6,500 and is compatible with our equipment.

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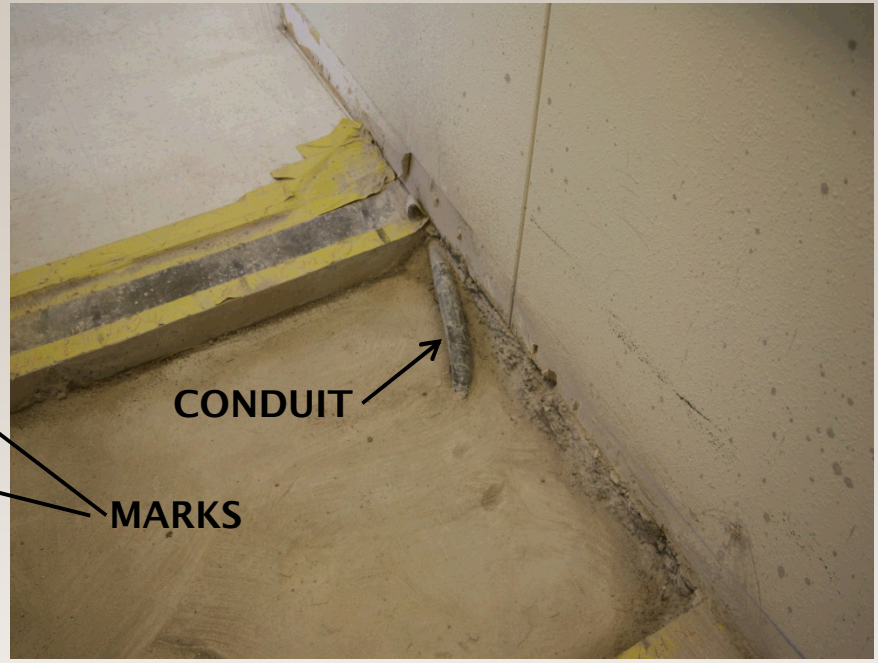
Errors and Lessons Learned



The conduit on the right was identified as an anomaly during the scan and marked in green, but the correct direction the object was traveling could not be identified. Experience should improve the ability to interpret these types of objects, and the palm antenna will help with these types of applications.

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Errors and Lessons Learned

- The photos above show areas that cannot be scanned due to the existing conditions.
- The area on the left is too small an area for the equipment currently used.
- The area on the right has a rough surface that affects the rolling of the antenna wheels on the cart. Smooth wheel movement is critical to accurately determine the location of the objects in the concrete by calculating distance and time.

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Anticipated Results

Penetration safety is increased safety for all when GPR can be used.

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  - Contractors will not necessary need to perform penetration work during off hours
  - Inspectors, Maintenance HV crews, Electrical Operations Engineers, and Ops-techs will not need to dedicate time associated with a scheduled outage
- Customers
  - No inconvenience from a scheduled outage (coordination, unable to work, shutdown and restart equipment, etc.)

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What are we working toward?

- Implementing processes to use GSSI equipment to assist in interior penetrations and help determine whether an electrical outage is required.
  - Process modifications to include where this tool should not be used
    - Within 6” of walls
    - On rough surfaces
    - Tight spaces
    - Congested areas
  - As a safety factor, no penetrations will be allowed within 1 inch of the center of the anomaly mark
- Procuring the GSSI Palm Antenna ($6,500)
  - Allows closer proximity to walls and ability to work in tighter spaces

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Recommendations

- Use GPR technology to support all interior penetrations as a best practice.
- Recommend formal training for all personal using GPR equipment.
- Continue monitoring and improving our process and expand the use of the GPR equipment.
  - Remain technologically current.
  - Utilize 3D scanning capabilities to add additional value to the scan.
  - Integrate with existing CAD drawings as information is gathered in the field.

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