Ground Penetrating Radar Technology and It's Use in Delayed Coking Units

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STRUCTURAL PRESERVATION SYSTEMS

STRONGPOINT ENGINEERING, LLC

Agenda

- Key Takeaways
- Explanation of GPR Technology
- Examples
- Limitations of GPR
- Onsite and Offsite Capabilities

Key Takeaways

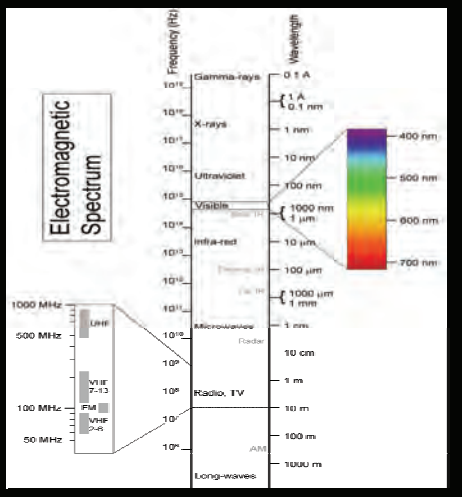
- Safety is an important consideration when working around an operating delayed coking unit
- What is GPR ?

What is GPR?

- Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface (ASTM D 6432)
- GPR uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum

Electromagnetic Spectrum

- Visible Light Spectrum
  - 400-790 THz = Wavelength of 390-750 nm
- GPR in 400-1600 MHz range
  - Wavelength around 90 to 30 cm (35-12 in)
- All light (in vacuum) travels at 299,792,458 m/s (6.706166E8 Mi/hr)
  - Less depending on the material



What is GPR? (cont.)

- GPR detects the reflected signals from subsurface structures
- GPR can be used in a variety of media, including concrete, rock, soil, ice, fresh water, pavements and structures
  - It can detect objects, changes in material, and voids & cracks

GPR Technology Limitations

- Limitations of GPR
  - Recent advances in GPR hardware and software have done much to address these disadvantages, and further improvement can be expected with ongoing development

GPR Technology Limitations (cont.)

- "Truth and Verification" is always recommended for NDT (Semi-Destructive Testing - SDT) by excavating a series of exploratory windows into the surveyed reinforced concrete element
- Correlation with additional NDT like Impact Echo Testing aids in validation of test results when SDT can't be performed due to hazardous conditions

Electromagnetic Energy

- Energy response dependent upon two material properties:
  1. Electrical Conductivity
     - Higher conductivity results in greater energy absorption and thus a weaker image

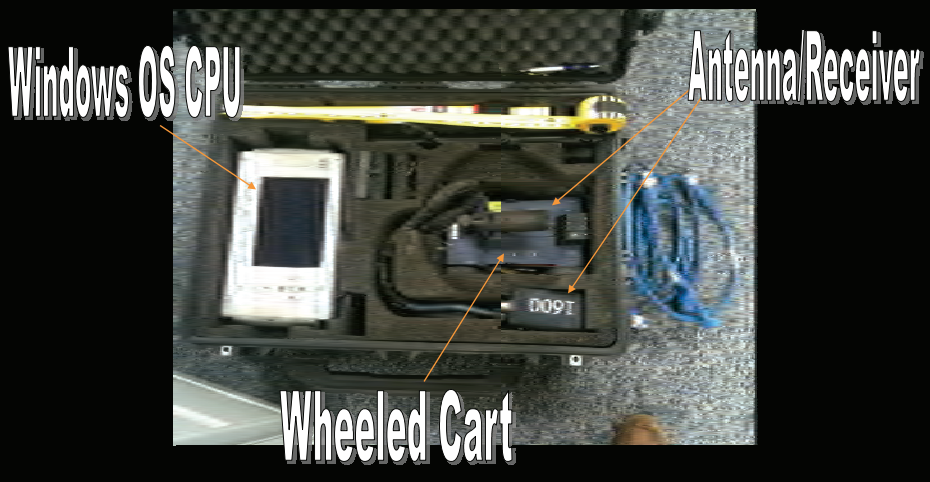
Electromagnetic Energy (cont.)

2. Dielectric Constant
   - Range from 1 (air) to 81 (water)
   - At 81, speed of light reduced to 1/9th original speed
   - Dielectric of concrete ranges from 3 to 12

Electromagnetic Energy (cont.)

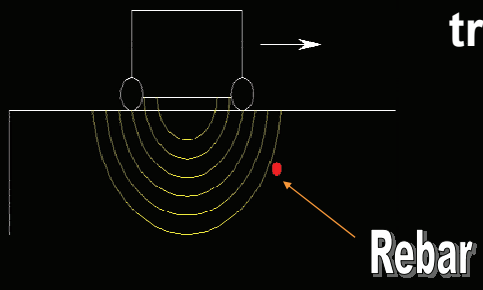
- GPR hardware detects differences in dielectric/speed of light
  - Primary readings will occur with material changes – specifically at interfaces:
    - ✓ Concrete/Steel
    - ✓ Concrete/Air

GPR Device



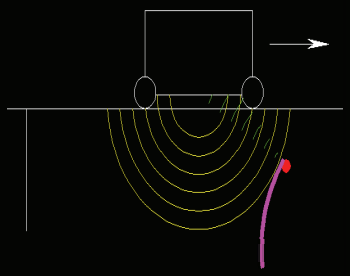
GPR Device (cont.)

- Radar waves travel from GPR

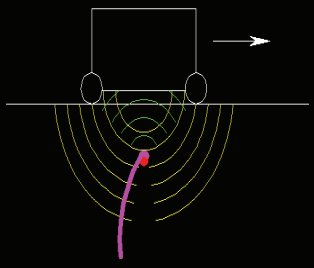


GPR Device (cont.)

- Radar waves travel from GPR
- Radar waves impact steel at distance and reflect back to receiver



GPR Device (cont.)



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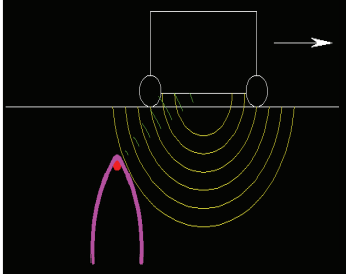
- GPR passes over steel, continuously taking readings

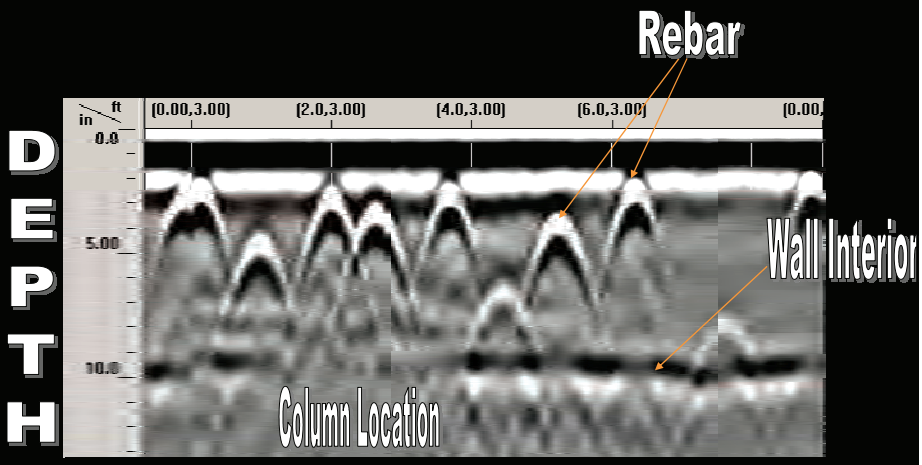
GPR Device (cont.)



- Radar waves travel from GPR
- Radar waves impact steel at distance and reflect back to receiver
- GPR passes over steel, continuously taking readings
- Creates a data hyperbole at the location of the steel
- <u>Dielectric contrast detected by GPR</u>

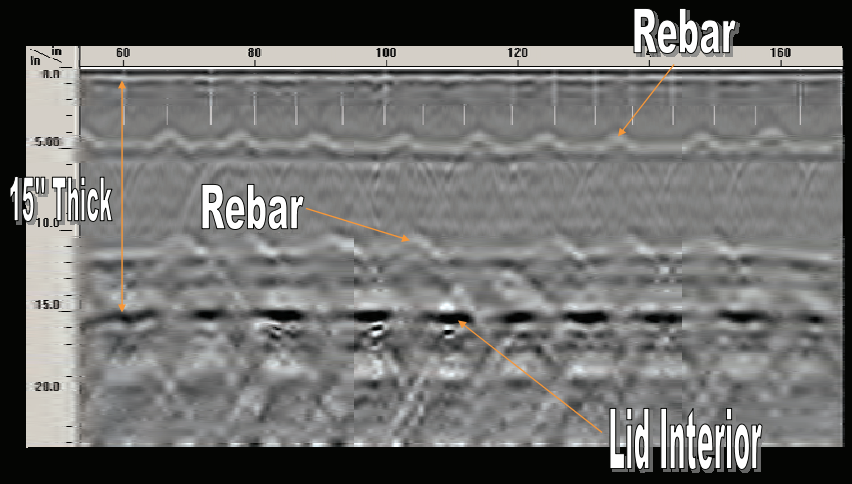
GPR Device Imaging

Grain Silo Wall, Age: 40 years



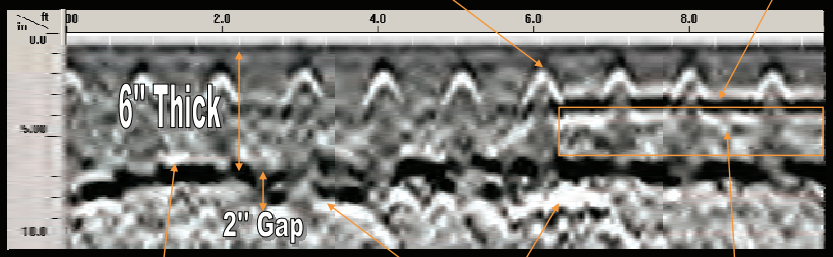
GPR Device Imaging

Sulfur Pit – Good Condition, Age: 20 years



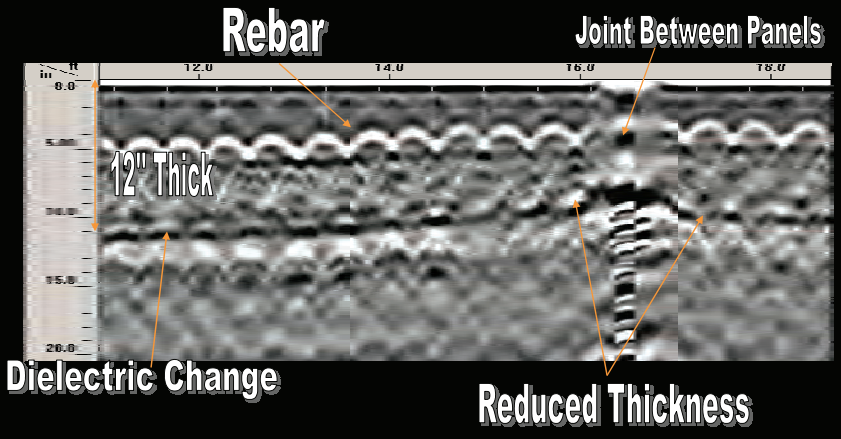
GPR Device Imaging

Sulfur Pit – Bad Condition, Age: 50 years



GPR Device Imaging

Sulfur Pit – Moderate Condition, Age: 10 years



GPR Testing/Survey Limitations

- Metals
  - Will obscure data below it (i.e., shadowing effect)
- Fluids
  - Will alter dielectric drastically
- Coke residue on reinforced concrete boundary surfaces can affect readings
  - Coke oil impregnates itself into the concrete matrix

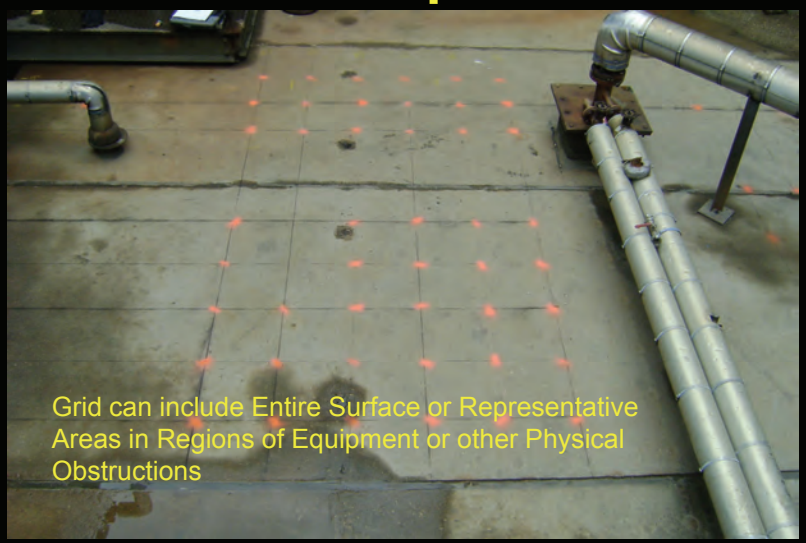
GPR Testing/Survey Limitations (cont.)

- +/- ¼'' Error (vertical/horizontal) typical on device
- Coke residue build-up can distort readings an additional ½''
- Delamination(s) can increase "Radar Signature Echoes" and further distort readings
- Cell phones, two-way radios, etc. adjacent to device will interfere with data collection

On-Site Capabilities

- Can detect an approximate thickness of a sulfur pit slab or wall
- Can determine rebar spacing, orientation, and approximate depth
- Can detect conduit, post tension cables, and subsurface piping

On-Site Capabilities

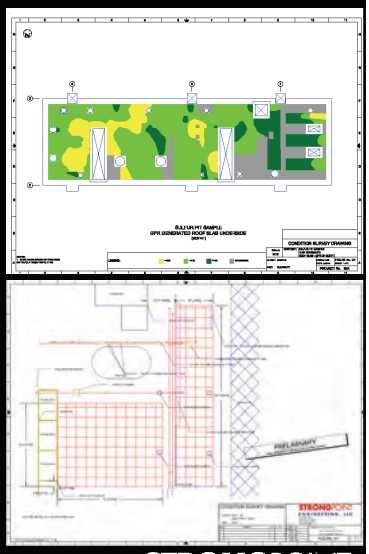


On-Site Capabilities

On-Site Capabilities

Off-Site Capabilities

- Can detect a more accurate Thickness of the Slab or Wall, with Composite Depth Contour Mapping
- Can determine Rebar Spacing, Orientation, and Approximately Mapped Locations onto CAD
- Can detect Conduit, Post Tension Cables, and Subsurface Piping and Approximately Mapped Locations onto CAD
- Can create 3-D, 'Section Cut' of Slab or Wall



GPR Survey Safety

- Preliminary scans performed from adjacent ground surface in voided regions
  - On-site verification of pavement slab thickness and/or void location
- Scaffolding installed over utility vault/pit roof slabs
  - Supported on pavement surrounding subsurface vaults/pits
  - Scans can be performed from scaffolding (with potential increased degree of error)
  - No additional loading to utility vault/pit roof slab other than GPR antenna
- GPR is battery-operated
  - Not an Intrinsically Safe Device (ISD)
  - Very low energy output – approx. 1% of ambient cell phone coverage waves

Sulfur Pit Inspection Scaffold Superstructure

Thank you!

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