GPR is a relatively young technology especially in use with roadways and bridges. At the current time, GPR is commonly used to ensure the proper depths of asphalt and concrete when laying roads. In the future, we see GPR being used to analyze the health of these roads, looking for voids, water pockets and delamination. These defects are commonly found around reinforcing steel. Metal completely reflects the radar signal, making defects obscured or difficult to read. Using computerized modeling tools allows us to subtract layers of GPR effects to highlight areas of concern. With the acquisition of a GPR computerized modeling tools allows us to subtract layers of GPR the radar signal, making defects obscured or difficult to read. Using computerized modeling tools allows us to subtract layers of GPR effects to highlight areas of concern. With the acquisition of a GPR system, we will be able to apply our knowledge to field data.


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Civil Engineering Undergraduate Summer Research Program,

Laura Carey, Kimberly Belli, Prof. Carey Rappaport, Prof. Sara Wadia-Fascetti
Northeastern University

Simulating GPR for Diagnosis of Civil Infrastructure

Abstract
At the present, a large proportion of our nation’s bridges and roadways are falling into disrepair. About 27.5% of U.S. bridges are structurally deficient or functionally obsolete (ASCE, 2001, 2003). Nondestructive testing methods, such as GPR, are becoming more and more important in diagnosing the condition of such concrete structures. GPR is a high-resolution electromagnetic technique used to investigate the immediate subsurface of the earth, building materials, roads, and bridges. This poster shows my work in GPR modeling during a summer undergraduate experience through CenSSIS. A specialized MATLAB toolbox designed by Kim Belli created all data presented here. The use of such modeling tools provides a deeper understanding of how GPR works and how to better interpret field data. The slides shown were taken from my concluding presentation given at Northeastern University on August 11, 2006.

Goals
• Learn how to create GPR simulations with a specialized toolbox in MATLAB.
• Create the bridge sample:

Accomplishments
• Simulating Seawater Filled Voids:

• Comparing Seawater and Air-Filled Voids:

Technology Transfer
On August 2, 2006, a SIR-3000 GPR system was donated to CenSSIS by Geophysical Survey Systems Inc. (GSSI). The SIR-3000 is equipped with a 2.2 GHz air coupled horn antenna. Fieldwork with this equipment will commence with the acquisition of a concrete test slab from Tufts University. Research done here at Northeastern University may influence the future design of GPR systems as well as create new applications for the use of this technology.

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Prof. Carey Rappaport
Prof. Sara Wadia-Fascetti
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Contributions to CenSSIS Research Thrusts
This work falls under CenSSIS Research Thrust R1 (subsurface sensing and modeling). Experiments with the SIR-3000 relate to the project to the CenSSIS SoilBED platform.

Electromagnetic Properties to See Beneath the Surface

• Improve and Refine Simulation Method
  • Make results more realistic
  • Improve user interface
  • Develop a set of tools to aid in the interpretation of data.

How Does It Work?
GPR uses a material’s electromagnetic properties to see beneath the surface
• Reflection
• Refraction
• Dielectric Constants

Table of Common Dielectric Constants
• Dielectric Constants

• Asphalt
• Dry Sand
• Air

Comparing Seawater and Air-Filled Voids:

<table>
<thead>
<tr>
<th>Deck w/ Rebar, Void</th>
<th>Rebar, Void Effects Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck w/ Rebar, Void</td>
<td>Rebar, Void Effects Only</td>
</tr>
</tbody>
</table>

• Learn how to create GPR simulations with a specialized toolbox in MATLAB.

Accomplishments
• Simulating Electric Field by the Timestep:

Accomplishments
• Insight into How GPR Really Works:

Why does reinforcing steel show up on the CenSSIS SoilBED screen as a hyperbola?

Table: GPR Uses a Material’s Electromagnetic Properties to See Beneath the Surface

<table>
<thead>
<tr>
<th>Material</th>
<th>Dielectric Constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>2.5 to 3.0</td>
</tr>
<tr>
<td>Dry Sand</td>
<td>6 to 12</td>
</tr>
<tr>
<td>Air</td>
<td>1</td>
</tr>
</tbody>
</table>

Comparing Seawater and Air-Filled Voids:

Air

Comparing Seawater and Air-Filled Voids:

• Seawater

Comparing Seawater and Air-Filled Voids:

• Seawater

Comparing Seawater and Air-Filled Voids:

• Seawater

Comparing Seawater and Air-Filled Voids:

• Seawater