2-1/2 DIMENSIONAL BI-STATIC GPR PROPAGATION AND SCATTERING MODELING OF ROADWAYS AND TUNNELS WITH PROJECTED 2D FDTD

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Abstract

Simulation Configurations

<table>
<thead>
<tr>
<th>Bridge Deck Model</th>
<th>Tunnel Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Thickness: 2.4cm</td>
<td>Sand Thickness: 3.5m</td>
</tr>
<tr>
<td>Asphalt EM Properties:</td>
<td>dielectric constant=5, conductivity=0.01</td>
</tr>
<tr>
<td>Concrete Thickness: 18.0cm</td>
<td>longitudinal and transverse ray</td>
</tr>
<tr>
<td>Concrete Properties:</td>
<td>diameter=1.8cm (64 rebars)</td>
</tr>
<tr>
<td>Transverse Rebar:</td>
<td>spacing=12.6cm on center, concrete cover=6.0cm</td>
</tr>
<tr>
<td>longitudinal Rebar:</td>
<td>diameter=1.0cm (56 rebars)</td>
</tr>
<tr>
<td>Air Void:</td>
<td>spacing=12.6cm on center, concrete cover=6.0cm</td>
</tr>
</tbody>
</table>

Excitation Reconfiguration

Filtering the 2D and 2.5D FDTD excitation signal to account for propagation variation at the simulated surface

\[
\begin{align*}
X(f) &= H_f(f) = Y_f(f) \\
X(f) &= H_f(f) = Y_f(f) \\
X(f) &= F(f) = H_f(f) \\
X(f) &= Y(f)
\end{align*}
\]

Computational Costs

- 3D case: 7 days and 3.6 computational hours per B-scan
- 2D and 2.5D: 48.0 minutes per B-scan

Summary

- Excitation reconfiguration leads to field calibration at deck surface
- 2D and 2.5D simulations adequately capture 3D observed scattering
- 2D and 2.5D healthy response can be used to approximate 3D healthy response with much less computation time
- Noticeable difference is present for cases with defect beneath rebars
- Accuracy of 2D and 2.5D model degrades for complex geometry configuration and out-of-plane T/R locations

Related Work


Future Work

B-scans are continuing to be generated in 2.5D and 3D simulations for alternate receiver heights in the tunnel model. This is aimed at improving the correlation between the 2.5D and 3D cases. Currently these correlations are made based on comparison to a known library of responses. It is hypothesized that through analysis of both X-directed and Y-directed responses we can develop a procedure for determining the subsurface object orientation angle relative to the direction of GPR motion 8, which is unknown in prior field-collected data.