MINNESOTA GPR PROJECT 1998

Report:

TH28, Burtrum, District 3

ROADSCANNERS OY
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Background

TH 28 road pavement structure is a conventional AC road, which has previously been widened using mixed soils. Today the road has several differential frost heave problem sites at different road sections. The purpose of the GPR survey in the TH 28 was to detect base and subgrade problem areas and to find reasons for them.

Surveys

A 400 MHz ground coupled antenna GPR survey was performed on May 20, 1998. The four test sections measured were:

1. MP 121+00 to 122+0.26
2. MP 119+0 to 120+0.35
3. MP 117+0.8 to 118+0
4. MP 111+0.9 to 112+0

Eastbound and westbound lanes were measured in the middle of each lane with 60 ns time window and 10 scan/m sampling density.

The road had soil boring information collected previously of the road and also a FWD survey was carried out on the West Bound lane. Visual distress information was also used for the interpretation.

Results

The parameters used for the interpretation and depth calculations are presented in table 1 and these parameters matched quite well with the reference data, only asphalt dielectric value was a little bit too high for some locations. The 500 MHz antenna is not designed for pavement thickness evaluation any way.
Table 1. CSH 48 layers and their dielectric values

<table>
<thead>
<tr>
<th>Interface</th>
<th>Dielectric value</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>6.5</td>
<td>400 MHz antenna gives only a rough estimate of asphalt thickness</td>
</tr>
<tr>
<td>Base</td>
<td>8</td>
<td>Base material is the material under the asphalt, base layer is considered to be relatively dry and base / sub base interface has strong reflection.</td>
</tr>
<tr>
<td>Sub Base</td>
<td>12</td>
<td>Sub Base includes all the materials above subgrade, except thick embankments.</td>
</tr>
<tr>
<td>Soil layers</td>
<td>12</td>
<td>A general dielectric value of 12 was used for each soil</td>
</tr>
</tbody>
</table>

The interpretation of West Bound lane GPR data together with FWD and drill core data is presented in appendix 1-4. The problem in the interpretation was that in some reference and GPR data there was some confusion, as to what was West bound lane and what the East bound lane, so that there is no 100% guarantee that the interpreted sections are from the same lane. However the interpreted GPR profiles match this way quite well with the FWD and Drill core data.

Section 1.121 to 122+260

The section starts from the small town and the distance follows the increasing mileage. The road has quite thin structures on the first 160 m section; AC and a base made of loamy sand and gravel. From 160 m to 1440 m beneath the base is one more layer on the top of the subgrade soil. This layer is made of loamy sand and gravel or loamy sand. Subgrade soil in section 0 – 380 is sand loam with no bearing problems. From 380 m to 620 m deflection bowls and GPR data show that there might be a soft subgrade layer beneath the road structures.

After 620 m there is an 80 m long better section with loamy sand and gravel subgrade, which changes sandy loam at 700 m and in that interface GPR data shows disturbed road structures indicating frost heave problems. After 700 m surface deflections are very high up 890 m indicating weak road structures. The next section 890 – 1020 m has clay subgrade but the road seems to be relatively good shape according to the deflection bowls. From 1020 forwards the subgrade is loamy sand and sandy loam up to 1425 m where subgrade changes to clay which can be seen also in the deflection bowls as very high deflections of the geophones near to the plate.

The worst frost heave problem area is located from 1820 m to 1850 where clay subgrade changes to loamy sand. This type of interface with two subgrade soils both with a different type of frost behavior is very typical to form frost damages and the road can be rehabilitated by constructing a transition wedge in the road.
Section 2. 119 to 120+0.35

This section has very heterogeneous subgrade soils causing different kinds of problems to the road. The subgrade has most likely organic material layers (peat?) in the first 120 m section of the road which can be seen clearly from the FWD bowls. The first frost damage area is located between 165 and 202 m, which is located on a tiny hill. The GPR data indicates that the subgrade soil in this section is most likely boulder clay (glacial till with boulders) which is very frost susceptible. Drill core information with loamy sand and gravel with aggregates indicates same kind of soil. According to the GPR data other locations where boulder clay appears enough close to the surface that it could cause frost heave damages are 240-250 m, 540-560 m, 650-670 m and 740-820 m.

From 280 m to 500 m the road passes two locations with settlements that have been made even through the years by adding more material on the top. The reason for these settlements are the very thick organic material (peat) layers deeper in the subgrade, which are indicated also by the FWD deflection bowls.

After 540 m to 910 m the subgrade changes from clay to loamy sand and deflection bowls show a very weak road structure. From 910 m to the end of the section the road is constructed on higher embankment.

Section 3. MP 117+0.8 to 118+0

The first 80 meters of this section the road is constructed on embankment. After that the road lies from 80 m to 240 m on a soft subgrade which can be seen on the FWD data. The next road section 240 to 610 lies also on a soft subgrade but the road structures are thicker and partly on higher embankment. The road section 620 – 660 m has severe frost damages which indicate damages related to the change of subgrade soil.

Section 660 – 900 m indicates soft subgrade and weak road structures, which is reflected to the road surface. Last section, 900 – 1100 is constructed on higher embankment.

Section 4. MP 111+0.9 to 112+0

Section 4 starts from the road intersection and first problems are located in the culvert area at 60 m. The road starts to have bearing capacity problems from 200 m to 320 m and at the end of this section there are slight settlements. From 320 m to 700 m the subgrade soil is mostly loam and sandy loam and deflection bowls show bearing capacity problems starting from 480 m.

After the junction of Todd CR 19 at 550 m the road becomes much worse, which can be seen on the FWD deflection bowls and subgrade is especially weak 940 m. However clear signs of differential frost damages cannot be seen in this section. All the damages seem to be related with weak subgrade soil.
Appendix 1