



Site Investigations with GPR: Implementation Recommendation

What We Did...

The use of air-launched ground penetrating radar (GPR) is well established within the Texas Department of Transportation (TxDOT). The limitation of this technology is that the depth of penetration is limited to the top 2 feet of pavement structure. Ground-coupled GPR has been used in Texas primarily for localized defect detection (such as locating buried tanks or subsurface springs). The ground-coupled GPR systems have a distinct advantage in that they can penetrate much deeper into the structure and provide meaningful information about changes in subgrade layers.

In the initial phase of the research, the Texas Transportation Institute (TTI) developed a field test



Figure 1. TTI's Combined Air-Launched and Ground-Coupled GPR Unit.

unit which was capable of simultaneously collecting both air-launched and ground-coupled data. This unit is shown in [Figure 1](#).

The biggest problem with GPR is in the area of data processing. Data collection is relatively straightforward, but the challenge is in converting the acquired GPR signals into information of use to pavement engineers.

To achieve this, TTI used two "state of the art" GPR signal processing packages: first, the COLORMAP system, which has been used extensively in Texas for processing air-coupled GPR data; and second, the Road Doctor™ package, which was developed in a joint effort between the Finnish National Roads Administration (FinnRA) and Roadscanners Inc.



The Road Doctor™ software package is the most comprehensive GPR data analysis and integration package available. It provides the capabilities of merging subsurface GPR images with a range of surface and structure information such as:

- pavement roughness information,
- pavement structural strength information as measured by the falling weight deflectometer (FWD),
- pavement surface condition information as measured by TxDOT’s Pavement Management Information System (PMIS) system, and

- drill log information.

Within Road Doctor™ it is possible to extensively annotate the results either with the information collected along the highway (the presence of culverts, road signs, etc.) or with significant transition areas, such as the transition from a cut to a fill section. One example of a Road Doctor™ output is shown in [Figure 2](#).

What We Found...

In this research we collected GPR data on four TxDOT projects to demonstrate GPR’s use in helping TxDOT engineers in the pavement design process. A summary of each project follows.

- **Identifying changes in pavement structure of FM 2818.** The plan sheets were not available for a section of FM 2818 near College Station. The pavement was showing localized problems, and the district was planning to perform a rehabilitation of the section. It was therefore critical to identify the cause of the problem. An air-launched GPR survey rapidly determined that this pavement had several different structures. The problem areas were all associated with one of the structures. GPR was able to rapidly determine the limits of the problem areas. In the rehabilitation process, different

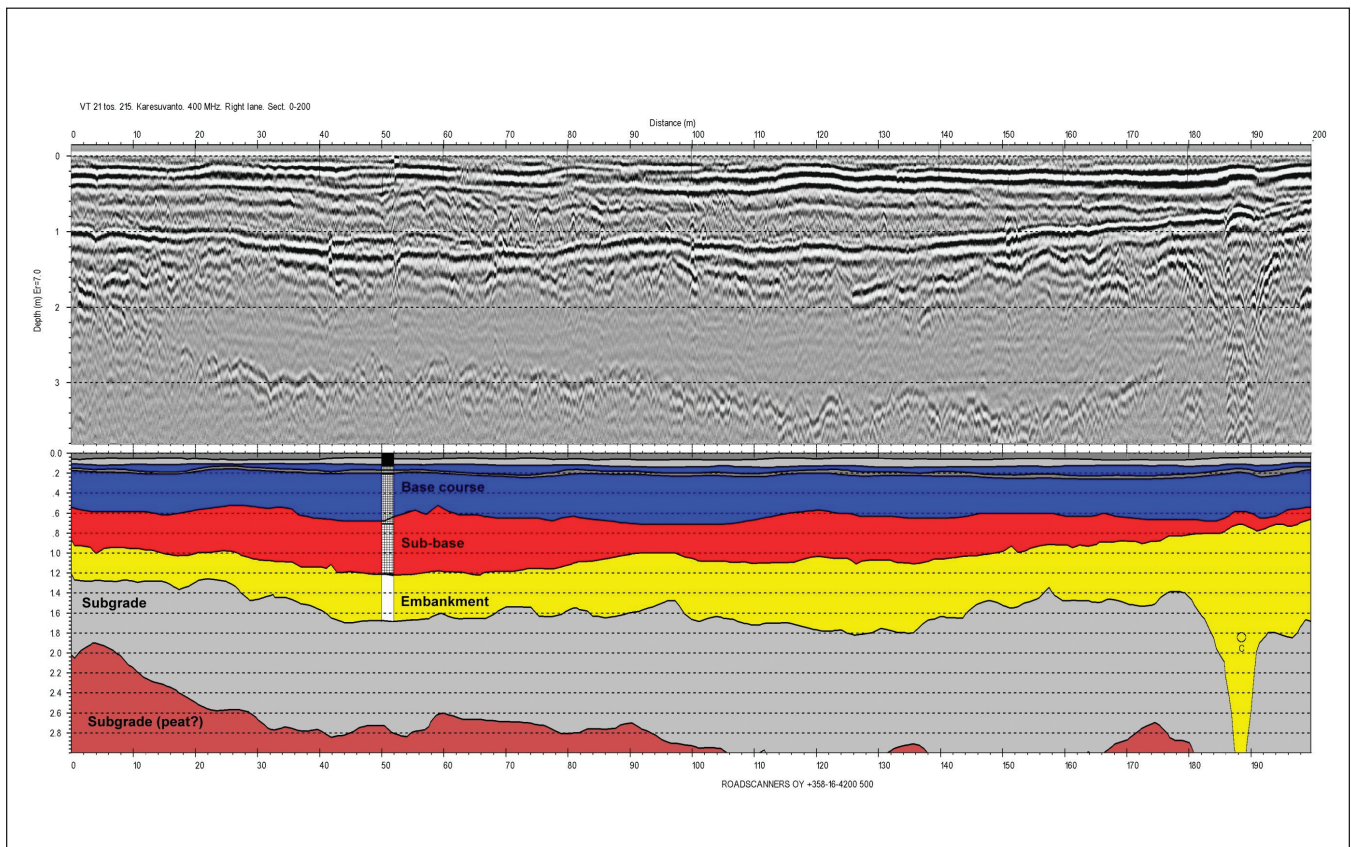


Figure 2. Road Doctor™ Output Showing Subsurface Layering to a Depth of 3 m.



strategies were applied to each of the structures.

- **Identifying moisture problems in a base layer.**

Surface cracking in northern parts of Texas is often associated with problems in the asphalt surfacing layers. In this case study from the Texas panhandle, researchers determined that the problems were not associated with the hot mix, but more associated with excessive moisture in the base layer.

- **Forensic investigation of a rapid pavement deterioration in SH 47.**

Both air-launched and ground-coupled data were collected to determine the cause of premature roughness on a poorly performing section of SH 47. The problems were found to be related largely to moisture problems in a lime stabilized subbase layer and the presence of extremely low-strength/saturated soil conditions. The subgrade was found to be a mixed layer of saturated zero plasticity index (PI) sand and very high PI plastic clay.

- **Locating areas of subsurface subsidence associated with mining operations.** Ground-coupled GPR was used to test an excessively rough section

of FM 488 near Fairfield, Texas. The major problems were largely caused by subsidence associated with strip mining operations. These sections were easily detected using the Road Doctor™ package.

It was hoped that ground-coupled data could be used by itself to identify major changes in soil beneath pavement structures. In some instances, this appears to be possible. For example, the transition from a wet clay to a dry sand can be detected. However, based on the experience on SH 47, this may not always be feasible. GPR was able to identify changes in subgrade layering, but it could not determine if the layer was high-PI clay or saturated sand. GPR is not sensitive to detecting minor changes in soil type such as a change from a PI 25 to 35 clay.

The Researchers Recommend...

The techniques used in this study should be attempted in other areas of Texas. In all GPR testing, it is essential to coordinate GPR results with field validation tests. In the case of ground-coupled testing, validation borings should be taken in locations where major changes in subsurface conditions are identified. The advantage of GPR testing is that it provides information about the entire

project, not only at locations where borings are performed. This technology should be used in coordination with the information available in United States Department of Agriculture (USDA) soil survey maps and from field boring to provide a comprehensive evaluation of soil conditions.

One drawback of ground-coupled GPR is that, unlike air-launched systems, it requires the use of a “GPR expert.” The process of selecting the correct antenna for any particular job, setting the correct data filtering and collection parameters, and cleaning up and interpreting the results needs more study. There are a wide variety of soil types, ground water, and environmental conditions in Texas which should be evaluated. More work should be undertaken to gain more experience in these areas.



For More Details . . .

This research project is documented in Report 4906-1, *Use of Ground Penetrating Radar for Site Investigation of Low-Volume Roadways and Design Recommendations*.

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The ground penetrating radar (GPR) with air-launched system is being implemented with IPR project 5-1702. IPR 5-1702 includes the purchase of GPR equipment and training for data collection and interpretation. The techniques for pavement analysis and design are being implemented by the districts using full depth recycling and IPR project 5-1712, "Flexible Pavement Rehabilitation Training Courses." The Construction Division is the Office of Primary Responsibility (OPR) for these implementation projects.

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Disclaimer

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