Using Radar to Investigate Roadbed

Inspection of the condition of the ballast and subgrade, below the surface of the ballast layer, is a difficult activity. The primary techniques used to investigate roadbed conditions include general observation of the track (i.e., looking for mud pumping, standing water, etc.) and "destructive" investigations of the roadbed, such as cross-trenching and boring. In the former case, the techniques are inexact and superficial, while in the latter case, they are time consuming and require digging up portions of the track. Neither case allows any detailed investigation of long stretches of track.

Research over the last several years has addressed an alternate technique for investigations of ballast and subgrade conditions. The technique uses a ground penetrating radar, mounted on a cart pulled behind a "hi-rail" vehicle, to inspect the roadbed and look for any anomalies or potential problems in the ballast and subgrade layers.

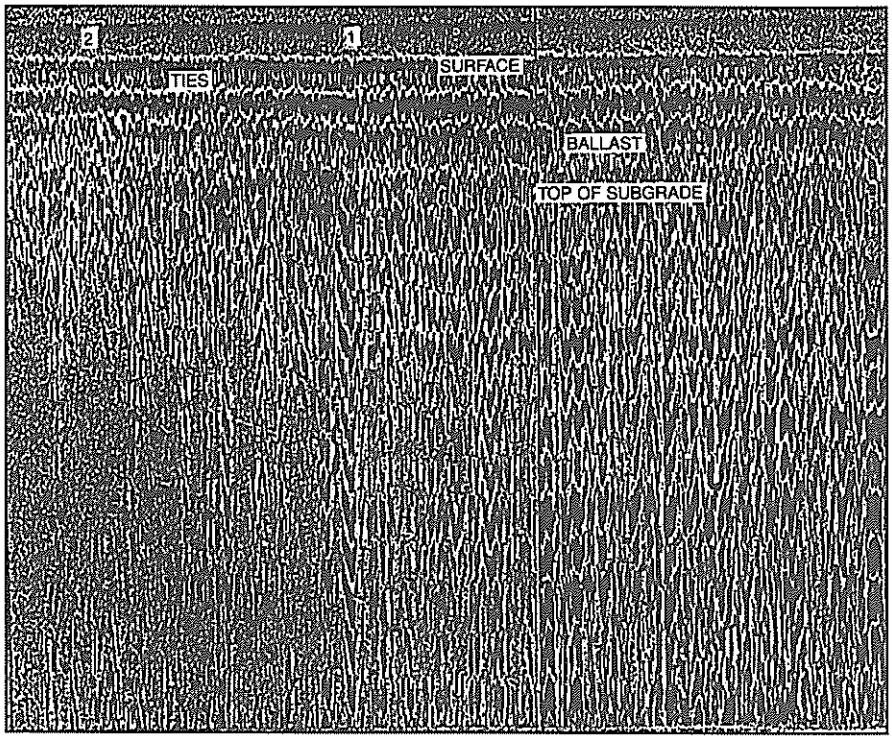

Figure 1 — Radar Ground Profile for Test Site

By use of an appropriately selected type of radar (such as pulse or swept frequency radars) operating at suitably selected frequency(s), it is possible to locate and define the distinct layers of the ballast and subgrade.[1,2] This is illustrated in Fig. 1 for a railroad test site with a well defined ballast layer and good subgrade condition. This, in turn, permits the determination of the actual depth of ballast in track, a value which is often not known for track that has been in service for a very long time.

The depth of penetration of such a radar system can be varied by changing the frequency of the radar signal. Through the use of an appropriately selected frequency, the depth of penetration can be varied from 3 ft. to several hundred.[1,2] However, for railroad applications, penetration depths of 30 ft. or less appear to be the most useful.

Because of the sensitivity of the radar to moisture content, it is possible to use such a radar system to detect the presence of sub-surface water in the track.[1,2] This potentially could include detection of large water pockets or detection of saturated soil conditions. Limited field tests have indicated that this is, in fact, feasible. Actually, it has been suggested that the variation in electrical properties between good and poor embankments (soils) could allow for the measurement of the physical properties (and in fact the foundation strength) of the embankment.[1]

One recent research study used a ground-penetrating radar system to monitor ground subsidence activity for railroad track.[3] In this application, excessive subsidence, followed by local "collapse" of the surface, was occurring at a site where dam construction resulted in the change in the hydraulic gradient. In this application, ground-penetrating radar was used to inspect and monitor the track in an attempt to identify the formation of vertical pipes found to be associated with

the subsidence. Fig. 2 illustrates one such radar profile showing both the presence of piping in the soil and the associated subsidence. Radar inspection every six months was continued as part of the ongoing field monitoring program.

Another reported application of the ground-penetrating radar is in the mapping of the extent of grout penetration during a grout drilling/injection operation.[3] This represents another area of application where the ability to "see" the extent of the injection can be used to insure that a sufficient (but not excessive) amount of injection is in fact carried out.

Another research activity addressed the ability of such a ground-penetrating radar to detect cavities or voids.[4] The thrust of this activity was toward paved surfaces, but it has applications for railroads. In this study, ground-penetrating radar was used to detect and map 28 cavities, varying in depth from 1.5 in. to 23 in. and in length up to 20 ft.

The use of ground-penetrating radar to detect subsurface anomalies was found to be feasible. However, this technique is still undergoing development. The outputs may require interpretation by a trained operator. They offer yet another tool for railroad maintenance officers.

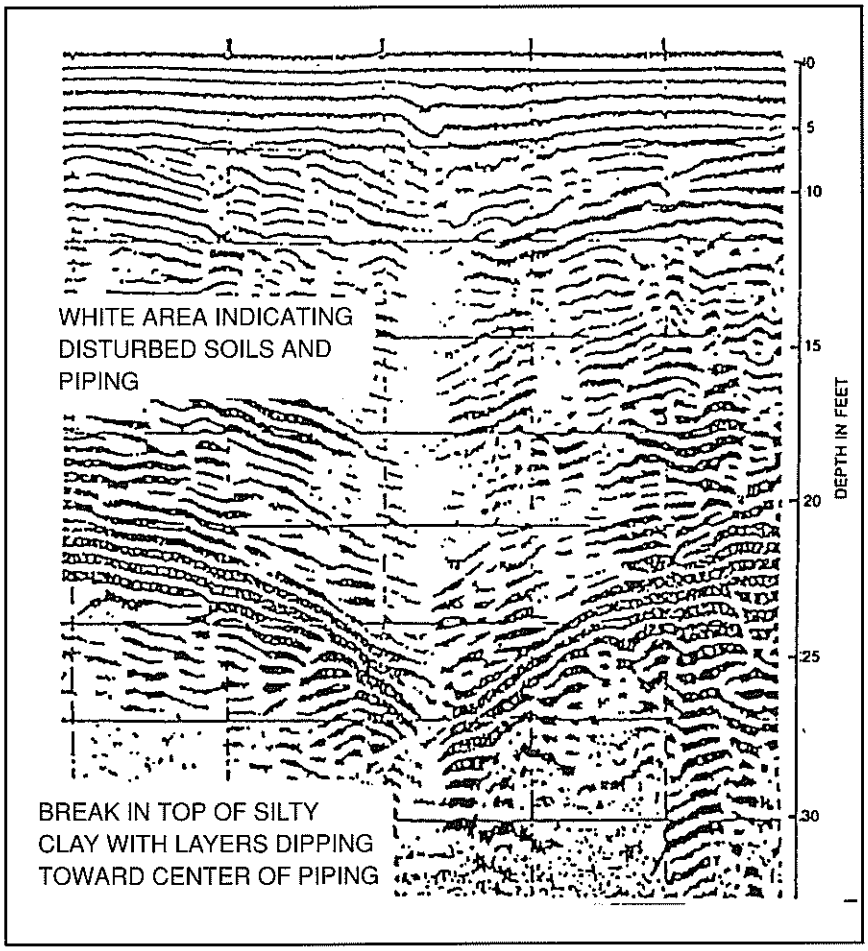

Figure 2 — Radar Data Showing an Advanced Stage of Piping and Subsidence

References

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2. So, W.; Hutcheson, T. B.; and R. F. Breese . " Field Evaluation of a Ballast-Subgrade Radar System," *Association of American Railroads Report R-428,* April 1980.
3. Benson, R. C., and L. Yuhr. "Assessment and Long Term Monitoring of Localized Subsidence Using Ground Penetrating Radar," *2nd Multidisciplinary Conference on Sinkholes and Environmental Impacts of Karst,* Orlando, FL, February 1987.
4. Kovacs, A. and R. M. Morey. "Detection of Cavities under Concrete Pavements," *U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory Report 83-18,* July 1983.