Cone Penetrometer Testing of Roadbed

Last month's *Tracking R&D* discussed the use of ground-genetrating radar to inspect the condition of the ballast and subgrade. Another technique that has been used on a limited study basis is on-site investigation of the subgrade using cone penetrometer testing.

The cone penetrometer test is an in-situ technique that determines the mechanical properties of soil strata by measuring the resistance of the soil and granular materials to penetration by a cone-tipped rod assembly. These resistance parameters are measured as a function of depth, as illustrated in Fig. 1, and include both tip resistance and local friction measurements. These values, in turn, can be related to the properties of the soil, and thus used to identify soil type,[1,2] such as defined by the Unified Soil Classification System (USCS). Fig. 2 presents one such relationship between cone penetrometer test measurement values and standard soil classifications.[1,2]

In addition, the cone penetrometer test values can be related to key soil properties such as the California Bearing Ratio (CBR)[3] which provides a good indication of the load carrying capacity of the soil. Both laboratory and field testing have confirmed that these cone penetrometer tests have high repeatability and sufficient sensitivity for use in practical material evaluation.[1,2]

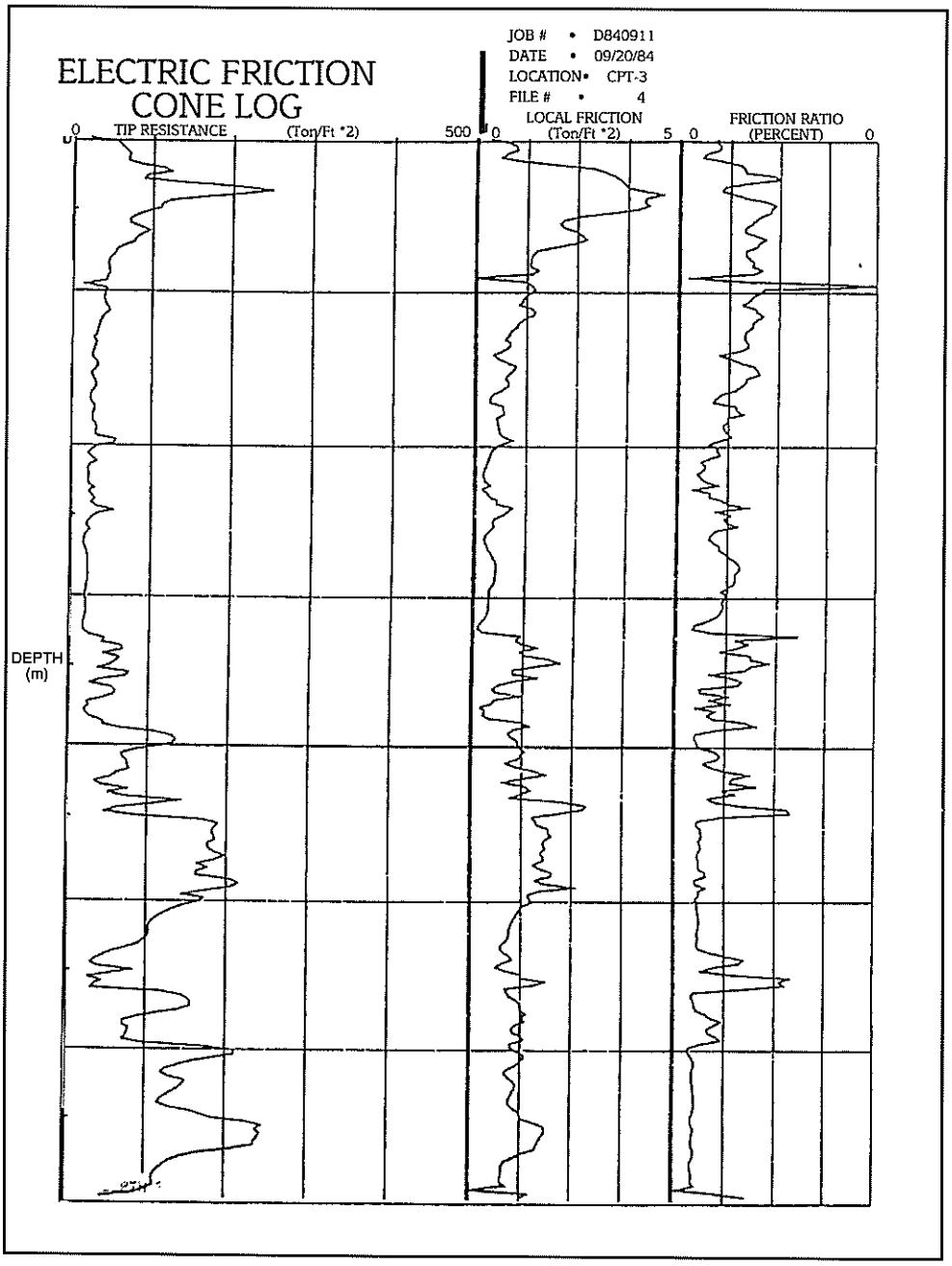

Figure 1 — Representative core penetrometer measurement

Several different types of cone penetrometers are available, including both mechanical and electronic systems, with corresponding trade-offs among accuracy, ease of use and cost. However, while these systems have been used in non-railroad applications for many years, dating back to the late 1940's,[2] their use in railroad applications has been relatively recent. This was partly due to the difficulty in using these systems in penetrating the ballast layer. However, recent applications have included the development of hi-rail mounted systems that can be used to directly penetrate the ballast layer and provide a direct set of measurement values with depth. Fig. 3 presents one such hi-rail mounted system developed by the U S. Army Corps of Engineers.

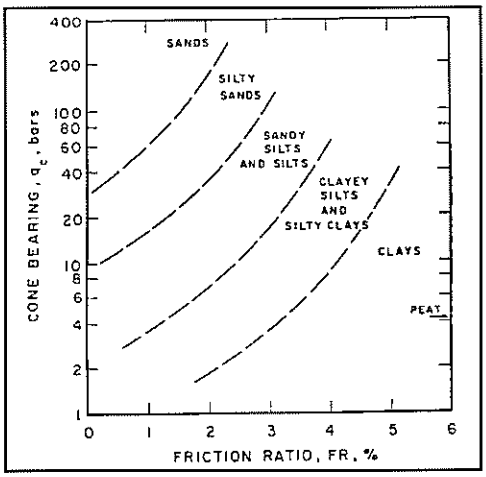

Figure 2 — Simplified classification chart for standard electric friction cone.

Figure 3 — Hi-rail mounted system from the U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS

Research into the use of cone penetrometer testing on railroads has shown correlation with soil conditions and with other types of soil measurement tests such as standard penetration tests.[4] Fig. 4 presents the results of one such set of tests near Streator, IL. Here, the cone resistance values are presented together with depth, soil descriptions, and standard penetration-test blow counts. (In this case, holes were bored through the ballast layers for all tests, thus results begin below the bottom of the ballast.) Note the correlation between the different tests and soil types.

In the railroad tests it was found that the cone penetrometer tests allowed rapid examination of many tests along the track.[4] Thus, these types of tests offer the ability to effectively and quickly investigate the condition of the subgrade in track problem areas, and to obtain accurate information about ballast and soil conditions without significant disruption of the track structure.

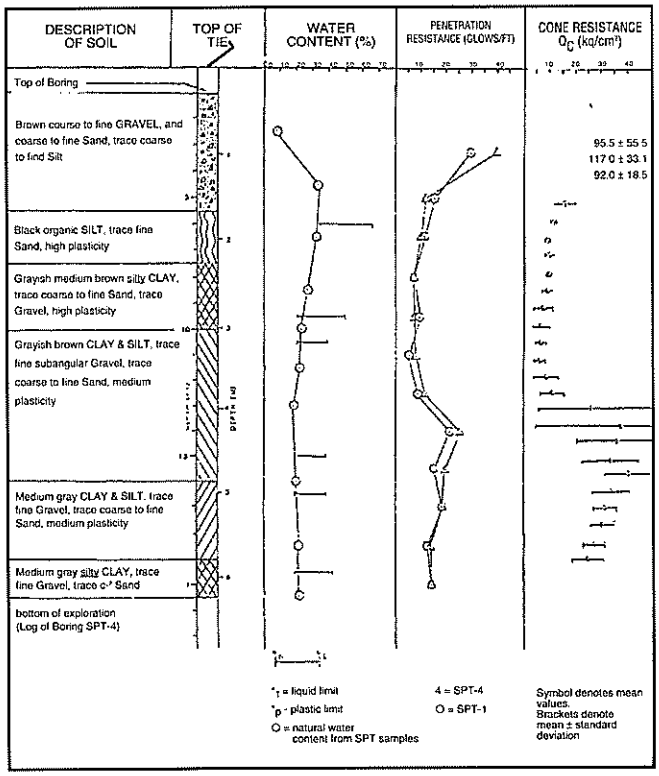

Figure 4 — Soil boring log for Streator wood tie site

References

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3. Livneh, M., and I. Ishai. "Pavement and Material Evaluation by a Dynamic Cone Penetrometer," *Sixth International Conference Structural Design of Asphalt Pavements,* University of Michigan, July 1987.
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