Unsaturated Characteristics of Fouled Ballast to Support in Situ Identification of Fouling

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Introduction

Fouling of railroad ballast leads to loss of ballast strength resulting in differential settlement of track; if fouling is not detected prior to loss of track geometry, then train derailment can occur. Current detection methods are destructive; geophysical methods are unreliable. Ground penetrating radar (GPR) can detect fouled ballast but cannot yet quantify ballast conditions. GPR measurements are a function of permittivity, which is greatly influenced by moisture and the degree of fouling. Soil water characteristic curves (SWCCs) show how fouled ballast respond to moisture at different fouling conditions. The first step toward improving GPR was to measure the SWCCs. Future work correlating SWCCs and GPR measurements will support the in situ identification of fouling.

Methods

- BNSF Railway and Metrolink donated fouling materials from track.
- Fouling materials were characterized using:
  - Grain size distribution (ASTM D6913, D1140, and D7928)
  - Atterberg Limits (ASTM D4318)
  - USCS (ASTM D2487)
  - Specific Gravity (ASTM D854)
  - Permeability (ASTM D5856 and D5084)
- Thermogravimetric analysis (TGA) was used to characterize fouling materials containing coal dust (Zhang, 2015).
- The transient water release and imbibition method (TRIM; Wayllace and Lu 2012) was used to measure the SWCCs of the fouling materials; the method models the SWCC by fitting a numerical model of unsaturated flow to unsaturated flow data measured in the lab. The van Genuchten (1980) model was used for all SWCCs.
- The Bouwer-Rice large particle correction procedure (Bouwer and Rice 1984) was used to predict SWCCs fouled ballast as a function of fouling; SWCCs of bulk samples with large aggregates (like fouled ballast) are calculated using phase relationships and the SWCC of the finer portion within the bulk sample (fouling materials).
- Fouling conditions were characterized using the Selig Fouling Index value $F_I$ (Selig and Waters 1994), and the void contamination index (VCI; Indraratna 2011).

Results

- SWCCs of ballast fouling materials show that presence of coal fines has great influence on water retention.
- Results for fouled ballast show that the type of fouling material and the quantity of fouling material in a fouled ballast layer dominate the engineering properties of the layer: water holding capacity and suction state.
- A large TRIM cell was built for testing fouled ballast, and the testing method was validated for fouled ballast.
- Future work correlating GPR dielectric constant with SWCCs is hypothesized to uncouple moisture and fouling influences on GPR measurements and interpretation; this would improve in situ identification of fouling.

Conclusions