INTELLIGENT COMPACTION BRIEF
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Texas FM156—Untreated and Lime Treated Cohesive Materials and Granular Base Materials—July 2008

PROJECT DATE/DURATION
July 20 to 25, 2008

RESEARCH PROJECT TITLE
Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base, and Asphalt Pavement Materials (FHWA DTFH61-07-C-R0032)

SPONSOR
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MORE INFORMATION
http://www.ceer.iastate.edu/research/project/project.cfm?projectID=-373342403

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INTRODUCTION

This demonstration was conducted on the FM156 project in Roanoke, Texas. The machine configurations and roller-integrated compaction measurement (RICM) systems used on this project included (Figure 1): a Case SV212 12-ton padfoot roller and a smooth drum roller equipped with roller-integrated stiffness ks measurement system with automatic feedback control (AFC), and a Dynapac CA362 15-ton smooth drum roller equipped with compaction meter value (CMV) measurement system with AFC. All the machines were equipped with real time kinematic (RTK) global positioning system (GPS) and on-board display and documentation systems. The project involved constructing and testing seven test beds with fine grained cohesive subgrade clay soils, lime treated cohesive subgrade clay soils, and granular base materials (flex base). The RICM systems were evaluated by conducting field testing in conjunction with a variety of in situ testing devices measuring: dry density (γd), moisture content (*w*), California bearing ratio (CBR), dynamic elastic modulus using a 200 mm plate light weight deflectometer ($E_{LWD\text{-}Z2}$) and a 300 mm plate falling weight deflectometer (E_{FWD}), initial (E_{V1}) and re-load modulus (E_{V2}) using a static plate load test with 300 mm diameter plate, and dynamic seismic pavement analyzer (D-SPA) low-strain elastic modulus ($E_{D\text{-}SPA}$). The goals of this field study were to:

- Evaluate the effectiveness of the RICM values from padfoot and smooth drum rollers in assessing the compaction quality of the three material types encountered on the project,
- Develop correlations between RICM values from padfoot and smooth drum rollers and various conventionally used in-situ point measurement values (MVs) in QC/QA practice, and
- Assess comparisons between smooth drum and padfoot roller RICM values.

Figure 1. (left) Case SV212 padfoot roller, (right) Case SV212 smooth drum roller, and (bottom) Dynapac CA362 smooth drum roller

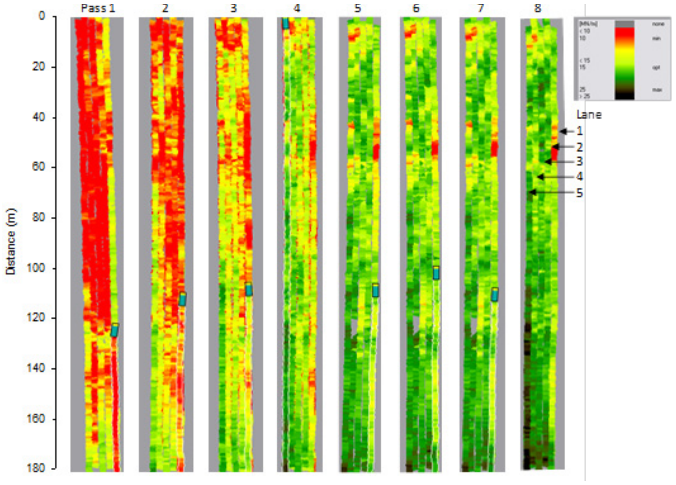

Figure 2. Screen shots of k_{SISD} maps for different passes on TB 1 – cohesive subgrade soil (from White et al. 2008)

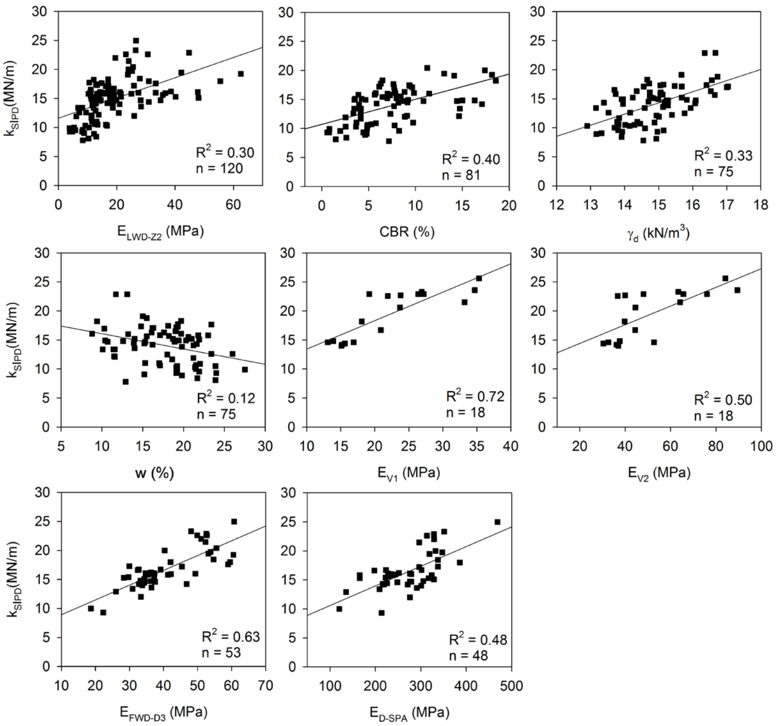

Figure 3. Simple linear regression relationships between k_{SISD} and in-situ point measurements (TB 1 – cohesive subgrade clay material) (from White et al. 2008)

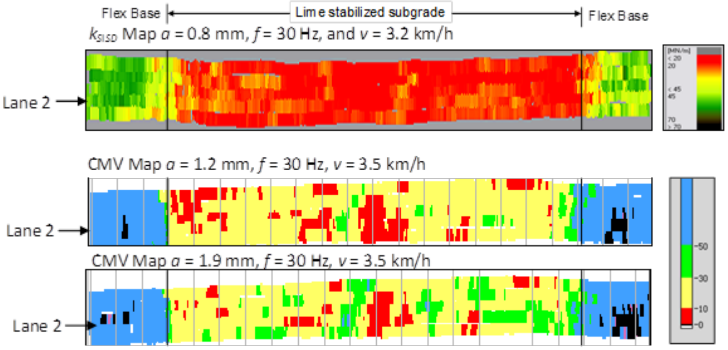

Figure 4. Comparison between k_{SISD} CMV maps– TB2 flex base and lime-stabilized subgrade (from White et al. 2008)

MATERIALS

The cohesive subgrade material was classified as lean clay (CL) and A-7-6(24) soil, the lime treated subgrade material was classified as silt with gravel (SM) and A-2-7 soil, and the flex base material was classified as poorly-graded gravel to silty gravel with sand (GP-GM) and A-1-a soil.

SUMMARY OF KEY FINDINGS

- Both padfoot and smooth drum roller-integrated k_s values (k_{sIPD} and k_{sIPD}) reliably indicated the compaction quality of the subgrade clay material with good repeatability. Correlations with E_{FWD} and E_{V1} values (with $R^2 > 0.6$) produced better R^2 values compared to E_{LWD-Z2}, γd, and CBR (of the compaction layer) measurements (e.g., Figure 3). Poorer correlations with E_{LWD-Z2}, γd, and CBR compaction layer values is attributed to the limitation of shallow measurement influence depth of these measurements (≤ 250 mm). CBR profiles up to 1 m generated from DCP tests identified "soft" zones below the compaction layer which affected the k_s values. The E_{V1} and E_{FWD-D3} are believed to have influence depths that extend below the compaction layer due to higher applied contact stresses at the surface.

- Both RICM values and in-situ point measurements captured the wide variation in stiffness of the compacted lime stabilized and flex base materials (Figure 4). A box-culvert located beneath the lime stabilized subgrade was identified with high roller MVs in that location (Figure 5). Linear regression relationships generally indicate separate linear trends for the lime stabilized and flex base materials. E_{FWD} measurements produced better correlations than other point measurements. Hyperbolic regression relationships were developed for E_{FWD} and E_{D-SPA} measurements which showed strong correlations with ks and CMV measurements but additional data is needed to validate the relationships. The CMV measurements at this location were highly repeatable.

- The ks measurements effectively identified poor backfill compaction conditions along the edge of a box culvert located in this test bed and the results were confirmed from CBR profiles (Figure 6). Regression relationships between ks and different in-situ point measurements show positive correlations with varying degree of uncertainty in the correlations (as assessed by the R^2 values), however. Better correlations were observed with E_{FWD}, E_{V1}, E_{V2}, and E_{LWD} values (with $R^2 > 0.5$) compared to E_{D-SPA} and γd. Relationships with E_{D-SPA} show encouraging trends in the data, however. The ks values were sensitive to moisture content of the compaction layer material.

- The roller-integrated CMV measurements showed good repeatability on the flex base material. Results from compaction passes did not show considerable increase in compaction with increasing passes. In some areas, the

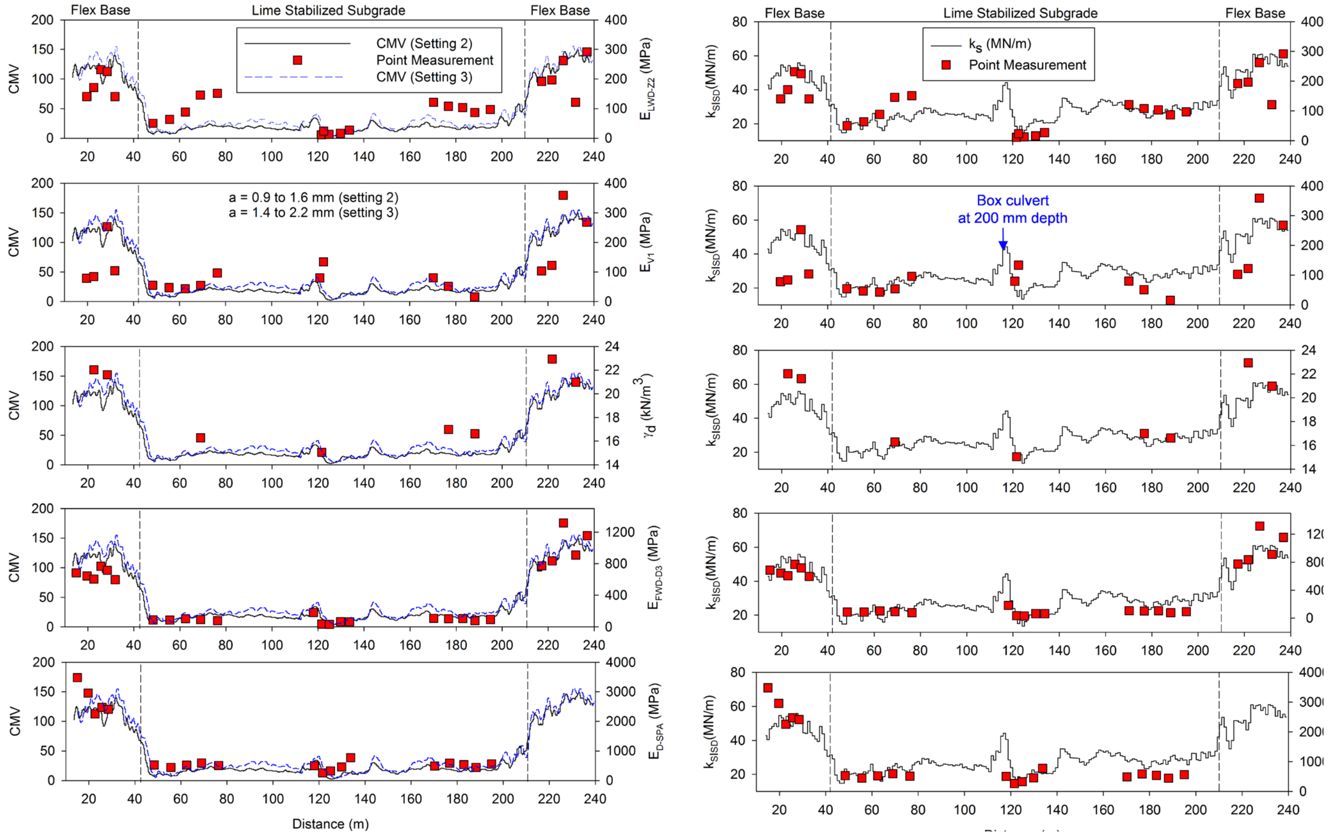

Figure 5. Comparison between k_{SISD} and in situ point measurements (left) and comparison between CMV and in situ point measurements (right) – TB2 flex base and lime-stabilized subgrade (from White et al. 2008)

material was wet and “spongy” during compaction passes. The CMV measurements obtained from this test bed were in the range of 20 and 70. The CMV measurements on TB2 flex base material which was very dry were greater than about 100. This indicates that the material gains significant strength over time as the material is subjected to several days of compaction under construction equipment and as it becomes drier.

- The CMV measurements are influenced by the vibration amplitude and show that increasing amplitude generally causes an increase in CMV on this material. Comparison between CMV and E_{FWD} measurements showed that the point measurements tracked well with the variability in CMV in some cases and in some cases it did not. The CMV measurements however were well correlated with variations in moisture content (within 4% to 6%) as evidenced by a decrease in CMV with increasing moisture content. E_{D-SPA}, E_{V1}, and CBR tracked well with the variations in CMV measurements. The reason for poorer correlation with E_{FWD} measurements in some locations is attributed to the possible influence of heterogeneity observed in the material across the drum width due to moisture segregation. Only one point measurement was obtained at the center of the drum while the roller value is an integrated response over the full drum width.

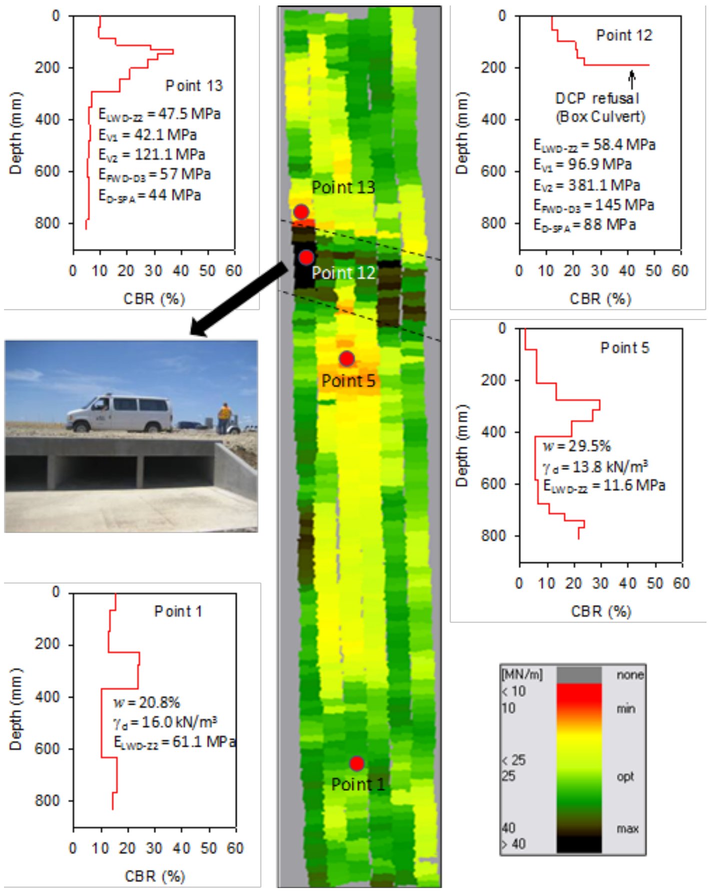

Figure 6. k_{SISD} map and DCP profiles at select locations on TB5 lime stabilized material (from White et al. 2008)

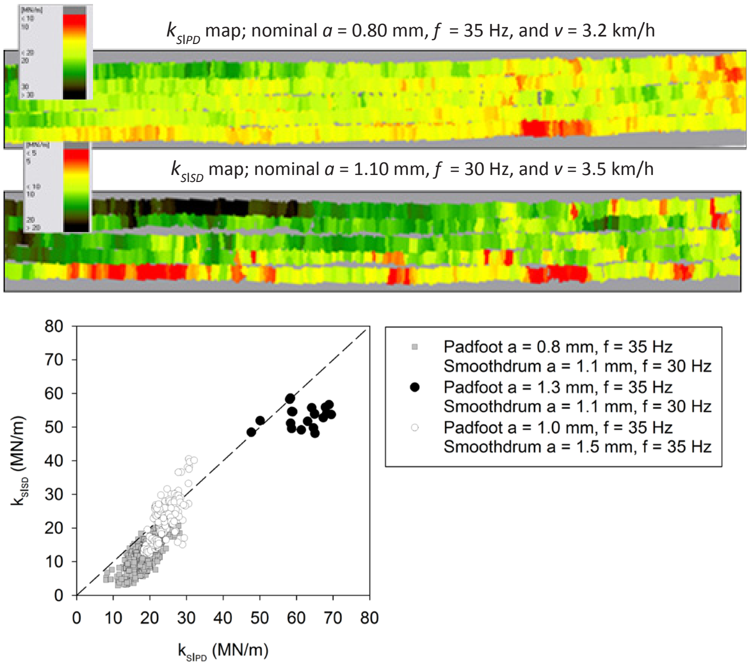

Figure 7. Relationship between k_{SISD} and k_{SISD} measurements (from White et al. 2008)

- Comparison between k_{sIPD} and k_{sIPD} show that k_{sIPD} values are generally greater than k_{sIPD} (Figure 7). Note that the values were obtained at different amplitude settings. Future studies may focus on obtaining correlations from the two measurements at similar amplitude settings. Comparison padfoot penetration depth measurements in conjunction with k_{sIPD} and k_{sIPD} measurements in future studies may help provide additional insights into the correlations between k_{sIPD} and k_{sIPD} values. Nevertheless, the trends observed between k_{sIPD} and k_{sIPD} are encouraging and the padfoot roller measurements demonstrate similar advantages as the smooth drum roller measurements.

REFERENCES

White, D.J., Vennapusa, P., Gieselman, H., Johanson, L., Goldsmith, R. (2008). Accelerated Implementation of Intelligent Compaction Monitoring Technology for Embankment Subgrade Soils, Aggregate Base, and Asphalt Pavement Materials TPF-5(128) - Texas IC Demonstration Field Project, Report submitted to The Transtec Group, FHWA, November.