Minnesota TH 36 – Granular Embankment Subgrade Fill – May-July 2007

RESEARCH PROJECT DATES/DURATION
May to July 2007

RESEARCH PROJECT TITLE
Implementation of Intelligent Compaction Performance-Based Specifications in Minnesota

RESEARCH PROJECT SPONSORS
Caterpillar
Federal Highway Administration
Minnesota Department of Transportation (MnDOT)

PRINCIPAL INVESTIGATOR
David J. White, Director and Professor
Center for Earthworks Engineering Research (CEER), Iowa State University,
ceer@iastate.edu, 515-294-5798

RESEARCH TEAM
David J. White
Pavana K. R. Vennapusa
Jiake Zhang
Heath Gieselman
Max Morris

AUTHORS
David J. White
Pavana K. R. Vennapusa

MORE INFORMATION
www.ceer.iastate.edu/research/project/project.cfm?projectID=-1995638463

This document was developed as part of the Federal Highway Administration (FHWA) transportation pooled fund study TPF-5(233) –Technology Transfer for Intelligent Compaction Consortium (TTICC).

CENTER FOR CEER EARTHWORKS ENGINEERING RESEARCH
IOWA STATE UNIVERSITY
Institute for Transportation

Figure 1. Caterpillar CS563 padfoot roller with CMV measurement system on TH 36 project (White et al. 2009)

Project Overview

The project involved reconstruction of TH 36 between White Bear Avenue and Century Avenue in North St. Paul, Minnesota. Reconstruction activities included a diamond interchange at TH 36 and McKnight Road intersection, and bridges for Margaret Street and pedestrian traffic over TH 36. Earthwork involved cuts and fills up to 5.5 m in height. Embankment materials used in the project were select granular base, granular subbase, and non-granular or granular "common" subgrade materials. The "common" subgrade material contained sandy soils with varying clay content.

The project implemented intelligent compaction (IC) pilot specification titled *Mn/DOT 2106 – Excavation and Embankment – (QA/QC) IC Quality Compaction (Pilot Specification) for Granular and Non-Granular Embankment Grading Materials*. A Caterpillar CS563 smooth drum roller equipped with compaction meter value (CMV) technology, real-time kinematic global positioning system (GPS), and AccuGrade compaction mapping system were used on this project.

Four calibration test strips were constructed and tested as part of a field study on this project by Iowa State University (ISU) researchers. Four in situ point test methods were evaluated in this study, which included (a) falling weight deflectometer (FWD), (b) light weight deflectometer (LWD), (c) dynamic cone penetrometer (DCP), and (d) piezocone static cone penetration test (CPTu). In addition, two test sections were instrumented with piezoelectric earth pressure cells (EPCs) to measure in situ vertical and horizontal stresses at different depths up to 1.20m. The objective for instrumenting the test sections was to develop comparisons between measurement influence depths for the different tests under roller-induced vibratory loading and LWD and FWD impulse loading. Empirical relationships between FWD, LWD, DCP, and CPTu point measurements and CMV measurements are developed in this study. Some key aspects regarding interpretation of the CMV measurements and selection of appropriate in situ test measurements when developing correlations are explored. Detailed results are presented in Vennapusa et al. (2011) and White et al. (2009). A few highlights from this project are presented in this tech brief.

Materials

Granular base, subbase, and subgrade materials were tested in this study. Granular base material was classified as well graded sand (SW or A-1-b), granular subbase was classified as poorly graded sand (SP or A-1-b), and granular subgrade was classified as clayey sand (SC or A-2-4).

Key Findings From the Field Testing

- The measurement influence depth under the roller in low and high amplitude setting (0.85 mm and 1.70 mm) loading conditions is estimated as about 0.9 m for the pavement structure tested in this study with 0.15 m thick base underlain by 0.35 m thick subbase and embankment subgrade. However, the contact stresses under the roller in high amplitude setting (1.70 mm) were 25% higher than in low amplitude setting (0.85 mm).
- The measurement influence depth under the 300-mm diameter FWD plate is about 0.6 m, and under the 200-mm diameter LWD plate is about 0.3 m.
- Results in this field testing revealed the following in terms of the magnitude of applied vertical and horizontal stresses: (a) the magnitude of stresses developed under a 300 mm diameter FWD plate with 53.4 kN applied force are similar to the magnitude of stresses developed under the roller with high amplitude setting (1.70 mm) loading, (b) the magnitude of stresses under LWD loading are significantly smaller than under roller and FWD loading, and (c) the magnitude of stresses under LWD loading are somewhat similar to the AASHTO T-307 resilient modulus (M_r) test loading and the initial sequences of the NCHRP 1-28A M_r test loading.
- Empirical correlations between CPTu, FWD, and DCP measurements produced relationships with $R^2 > 0.6$. Similarly, empirical correlations between FWD, DCP, and roller CMV measurements produced R^2 values close to 0.6. The correlations are believed to be affected by differences in stress states in the foundation materials under FWD and LWD loading.
- Roller jumping as measured by resonant meter value (RMV) affected the CMV values and consequently the correlations. A statistically significant correlation was possible in this current study by incorporating RMV into a multiple regression model to predict CMV. However, for practical implementation purposes, it is recommended that calibration testing be performed in lower amplitude setting to avoid complex interpretation and analysis of results with roller jumping.

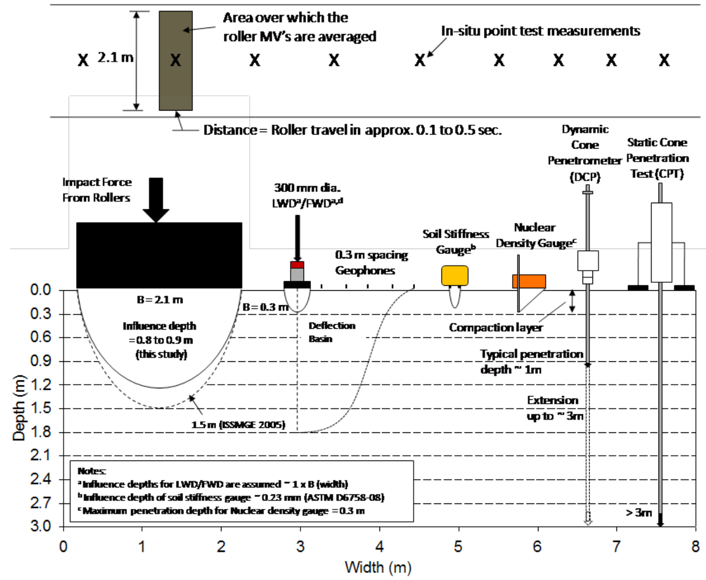

Figure 2. Illustration of differences in measurement influence depths of different testing devices (White et al. 2009)

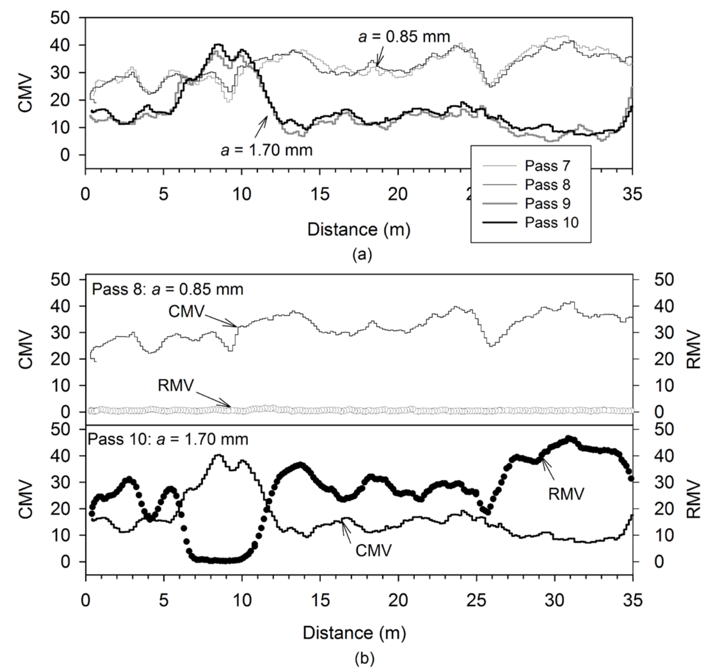

Figure 3. Histogram plots of moisture content, LWD, and MDP measurements (White et al. 2009)*

References

White, D. J., Vennapusa, P., Zhang, J., Gieselman, H., and Morris, M. 2009. *Implementation of Intelligent Compaction Performance Based Specifications in Minnesota*. Minnesota Department of Transportation, St. Paul, MN.

Vennapusa, P., White, D. J., Siekmeier, J., and Embacher, R. 2011. In situ mechanistic characterizations of granular pavement foundation layers. *International Journal of Pavement Engineering*. First published on April 15, 2011.