Minnesota Route 4—HMA Overlay—June 2008

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

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

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Figure 1. Sakai SW880 smooth drum roller

INTRODUCTION

This demonstration was conducted on Route 4 in Kandiyohi County, Minnesota. A Sakai SW880 double drum roller (Figure 1) equipped with the Compaction Control Value (CCV) roller-integrated compaction measurement (RICM) system was used in this study. The machine was equipped with real time kinematic (RTK) global positioning system (GPS) and on-board display and documentation systems. The project involved mapping the existing subbase layer and the hot mix asphalt (HMA) overylay non-wearing and wearing course layers. The main goal of this study was to evaluate the influence of the subbase layer support conditions on the HMA layer CCV measurements.

SITE CONDITIONS

The project area consisted of approximately 1 to 3 m (3 to 10 ft) thick compacted subgrade material placed over the previous grade of Route 4. Reportedly, the subgrade layer over a portion of the project area "failed" under test rolling during construction in summer 2007. Later, the subgrade layer was capped with 150 mm (6 in.) of class 5 aggregate subbase material (Minnesota aggregate subbase classification). Since installing the subbase layer, the aggregate surface road has been open for traffic.

Kandiyohi County soil survey information (NRCS 2008) indicated that the majority of natural soils in the project area are derived from glacial till and glacial outwash materials. Portions of the project area consisted of muck herbaceous organic materials of Houghton muck and Palms muck soil series. These soils are very poorly drained with the water table at surface and typically have natural moisture contents in the range of 40% to 100%.

The approximate location of the area that "failed" under test rolling is highlighted on the soil survey map presented in Figure 2. The natural soils in this area consist of Palms muck soil series with sandy substratum which contained muck to a depth of about 0.7 m (27 in.) underlain by clay loam and sandy soils to a depth of about 1.5 m (60 in.), below natural grade. A review of project drawings indicates that approximately 1 m to 2 m (3 ft to 6 ft) of new subgrade fill was placed over the previous grade in this region.

SUBBASE LAYER AND HMA LAYERS MAPPING

The granular subbase layer was mapped in five roller lanes which included three roller lanes to cover the north bound (NB) and south bound (SB) pavement lanes, and two roller lanes to cover the NB and SB shoulders. The front drum was in vibration mode while the rear drum was in static mode during the mapping process. The vibration settings used were as follows:

- Subbase map 1: frequency, f = 2500 vpm, amplitude, a = 0.6 mm (high amp), v = 4.8 km/h (3.0 mph)
- Subbase map 2: frequency, f = 3000 vpm, amplitude, a = 0.3 mm (low amp), v = 4.8 km/h (3.0 mph)

The HMA non-wearing course layer was compacted using a = 0.3 mm and f = 4000 vpm in a few areas of the project, but most areas were compacted using a = 0.6 mm and f = 3000 vpm settings. Compaction was performed using two vibratory roller passes with both front and rear drums in vibration mode. (Note that only the front drum was instrumented with CCV system).

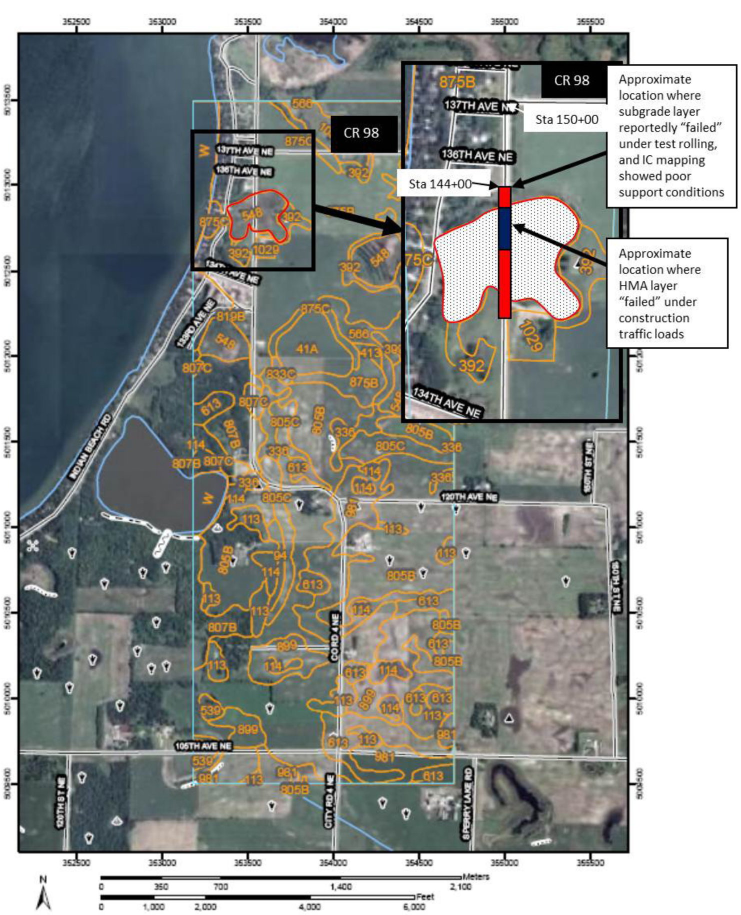

Figure 2. Aerial image with soil survey information of the project area (modified from NRCS 2008)

RESULTS AND ANALYSIS

Results indicated that CCVs on the shoulder lanes were lower compared to CCVs on the mainline. Average CCV on the pavement lanes was about 1.5 times greater than average CCV on shoulder lanes. Field observations indicate that the shoulders were not subjected to traffic, as vehicles were predominantly driven within the pavement lanes.

Figure 3 shows CCV maps of the HMA non-wearing course layer and the underlying subbase layer for a 210 m (700 ft) long section with heterogeneous subbase. Figure 3 also shows locations of high CCV and low CCV areas on the subbase layer reflecting on CCV measurements on the HMA layer. Regression relationships in Figure 4 indicate a statistically strong relationship between CCV measurements obtained on the HMA non-wearing course layer and subbase layer at a = 0.6 mm setting with R^2-value of about 0.7. CCV measurements obtained on the subbase layer at a = 0.3 mm showed relatively poor correlation to CCV measurements on the HMA layer.

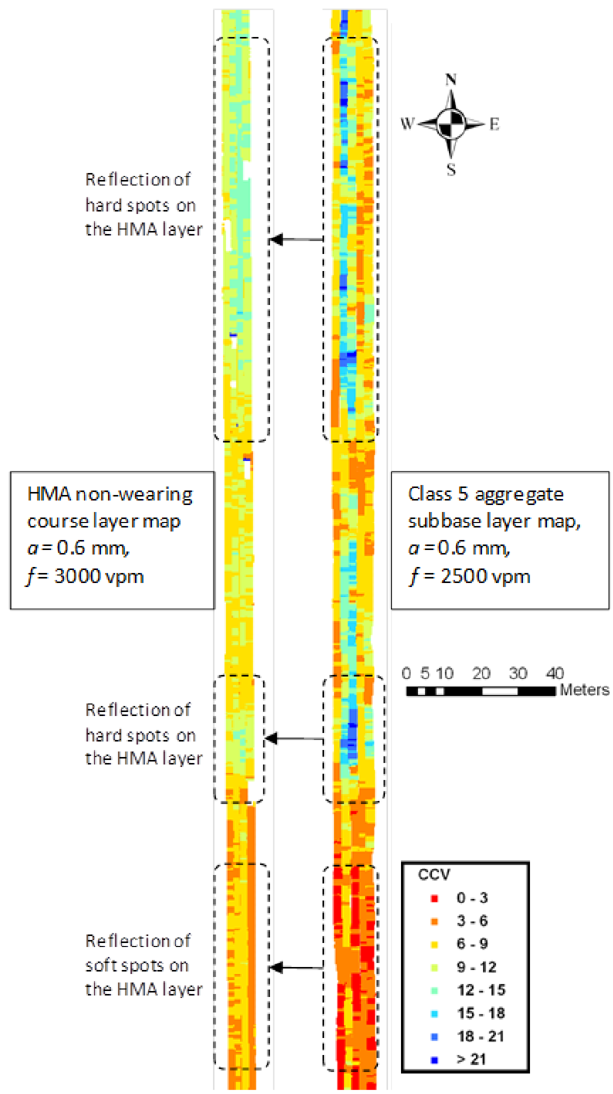

Figure 3. Comparison of HMA non-wearing course layer and subbase layer map showing the influence of underlying layer heterogeneity (from White and Vennapusa 2008)

Following compaction operations on the HMA non-wearing course layer on the SB lane, premature "failure" cracks were observed over a 200-ft long section on the HMA layer under construction traffic (Figure 5). To further evaluate the condition, the CCV measurements on the HMA wearing course layer and the subbase layer in this area were compared as shown in Figure 6. The data in Figure 6 show average CCV = 2.5 for the subbase layer, which is considerably lower than the project average CCV = 7.5. Average CCV on the HMA wearing course in the same area was about 5.2, which was also lower than the project average of about 6.9. This area is located within the area where the subgrade layer reportedly "failed" under test rolling in summer 2007. Again, the underlying natural soils in this section were identified in the soil survey as consisting of peat/muck soil deposits (see Figure 2).

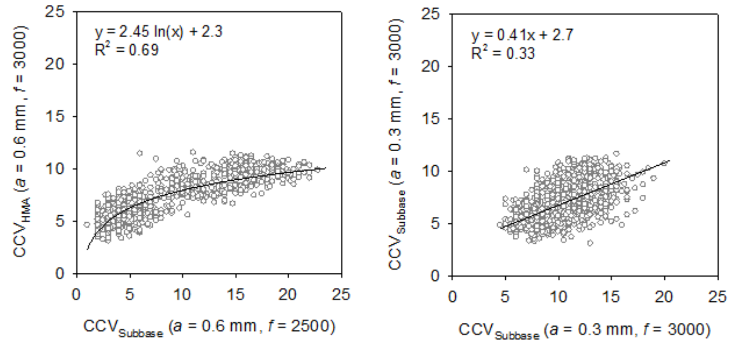

Figure 4. Simple regression relationships between CCV measurements on subbase and HMA non-wearing course layer (from White and Vennapusa 2008)

Figure 5. Premature failure observed in the HMA non-wearing course layer between Sta. 140+12 and Sta. 142+61 (from White and Vennapusa 2008)

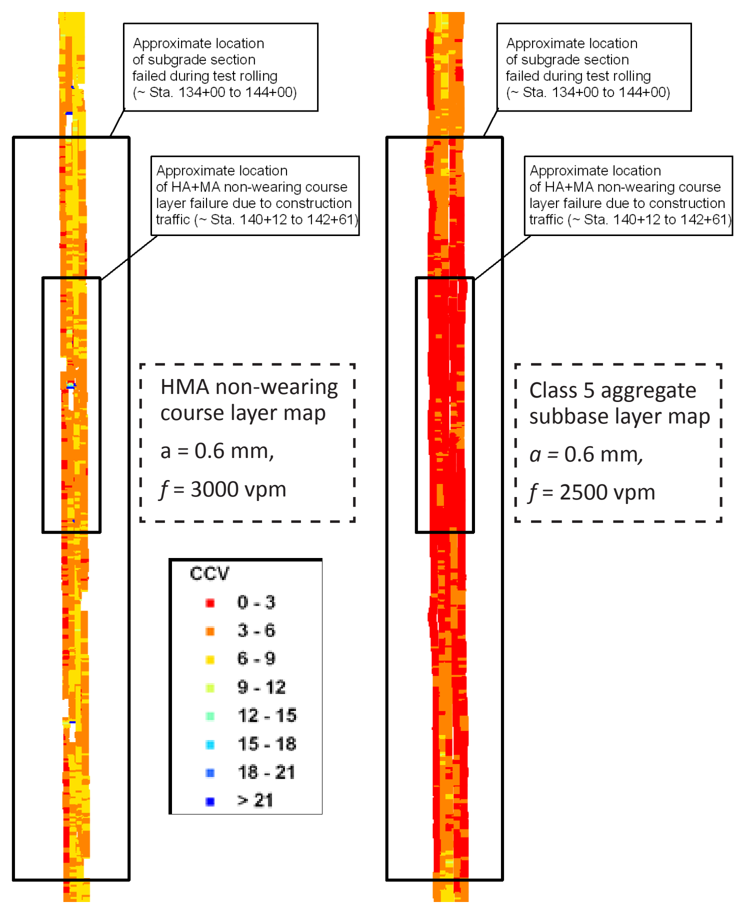

Figure 6. Comparison of HMA non-wearing course layer and subbase layer maps (from White and Vennapusa 2008)

SUMMARY OF KEY FINDINGS

- CCV measurements on the subbase layer at *a* = 0.3 mm setting were on average about 1.5 times greater than CCV measurements at *a* = 0.6 mmsetting.
- Comparison between CCV maps on the HMA non-wearing course layer and subbase layer showed several locations of high and low CCV that reflected on the HMA layers. Regression relationships between CCV measurements on the subbase layer on the HMA layer showed strong correlation. This demonstrates the importance of the knowledge of the underlying layer in interpreting CCV measurements at the surface, which has not been well documented in the literature.
- CCV measurements obtained on the subbase layer at 0.6 mm amplitude setting better distinguished the hard/soft spots compared to CCV measurements obtained at 0.3 mm amplitude setting.
- Following compaction and mapping of the HMA non-wearing course layer on the SB lane, premature "failure" cracks were observed over a 200-ft long section on the HMA layer. This area was located within the area where the subgrade layer reportedly "failed" under test rolling in summer 2007 and is an area underlain by peat/muck soils.

REFERENCES

White, D.J., and Vennapusa, P. (2008). Accelerated Implementation of Intelligent Compaction Monitoring Technology for Embankment Subgrade Soils, Aggregate Base, and Asphalt Pavement Materials TPF-5(128) – Minnesota Rt4 Project, Report submitted to The Transtec Group, FHWA, June.

NRCS (2008). Web Soil Survey, Natural Resources Conservation Service (NRCS), United States Department of Agriculture (USDA). <http://websoilsurvey.nrcs.usda.gov/ > accessed June 20, 2008.