Mechanical Stabilization of Subgrade Layer

RESEARCH PROJECT TITLE
Central Iowa Expo Pavement Test Sections: Phase I – Foundation Construction (InTrans Project 12-433)

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Federal Highway Administration

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The owa Department of Transportation (DOT) worked with its research partners to design comparative pavement foundation test sections at the Central Iowa Expo Site in Boone, Iowa. The p oject was constructed from May through July 2012. Sixteen 700 ft long test sections were constructed on 4.8 miles of roadway with the following goals:

- Construct a test area that will allow long-term performance monitoring
- Develop local experience with new stiffness measu ement technologies to assist with near-term implementation
- Increase the range of stabilization technologies to be considered for future pavement foundation design to optimize the pavement system

This tech brief p ovides an overview of in situ test results and key findings f om a mechanically-stabilized subgrade test section where the on-site reclaimed subbase layer was blended with the subgrade.

Background

Mechanical stabilization by mixing/blending granular subbase materials with wet subgrade soils and compaction can provide a stable working platform and foundation layer under pavements (Christopher et al. 2005). The mechanically-stabilized layer can exhibit lower plasticity, lower frost-heave potential, and higher drainage characteristics compared to subgrade soils (Kettle and McCabe 1985, Rollings and Rollings 1996).

Based on laboratory testing, Kettle and McCabe (1985) found that the magnitude of reduction in frost-heave is related to the coarse aggregate content and the type of aggregate used in the mechanically-stabilized layer. In addition, support capacity of a mechanically-stabilized layer is influenced y the degree of saturation and the percentage of clay particles present in the mixture (Hopkins et al. 1995).

The efore, post-construction changes in saturation (in part due to freeze-thaw) must be considered in understanding the long-term performance of a mechanically-stabilized layer. Hopkins et al. (1995) indicated that a soil-aggregate mixture must be designed to have a Kentucky California bearing ratio (CBR) ≥10 in the soaked condition but cautioned that this limiting condition must be viewed as very approximate.

In the present study, performance of a mechanically-stabilized layer constructed by mixing on-site reclaimed granular subbase material with wet subgrade soil was evaluated by measuring in situ engineering properties over time with a special focus on freeze-thaw performance.

Figure 1. Mixing a recycled subbase layer with the subgrade using a soil reclaimer

Description of Test Sections and In Situ Testing

The original p oject conditions consisted of a thin chip seal coat and 8 in. granular subbase (mixture of sand, gravel, and recycled asphalt) at the surface classified as SM or A-1-a (14% fines content) and a biaxial geogrid at the inte face of the subbase and subgrade. The unstabili ed subgrade material was classified as CL or A-6(5)

Within the project, 2nd St. North and South were selected for studying mechanical stabilization. The const uction procedure involved the following: (1) scarify and excavate the existing subbase layer down to the subgrade elevation and remove the biaxial geogrid, (2) place about 6 in. of the reclaimed granular subbase back onto the subgrade, (3) mix the reclaimed subbase with the underlying 12 in. of subgrade using a soil reclaimer (Figure 1), (4) compact the mixed layer with a vibratory smooth drum roller equipped with roller-integrated compaction monitoring (RICM) (Figure 2), and (5) place and compact a nominal 6 in. thick layer of crushed limestone-modified subbase

The mechanically-stabili ed subgrade material was classified as SC or A-2-6 (average fines content of about 33%). Th crushed limestone subbase layer was classified as GP-GM or A-1-a (7% fines content). radation curves of these materials and the reclaimed subbase and subgrade materials are presented in Figure 3.

In situ testing of the foundation layers was conducted prior to construction (May 2012), during and shortly after mechanical stabilization/compaction of the subbase layer (July 2012), after about three months (October 2012), and during and after the spring thaw (April and May 2013). In situ testing methods included light weight deflectometer (WD), dynamic cone penetrometer (DCP), falling weight deflectometer (FWD), and roller-integrated compaction monitoring (RICM). Selected test results from DCP, FWD, and RICM tests are presented in this tech brief. All test results are presented in the Phase I final eport.

Figure 2. Compaction of the subbase/subgrade mixture with vibratory smooth drum roller

In Situ Test Results and Key Findings

The mechanically-stabili ed subgrade layer was compacted using the RICM roller in three roller lanes (east, middle, and west). Compaction was performed using low amplitude (a = 0.9 mm) and high amplitude (a = 1.8 mm) settings. Linear plots of RICM data (i.e., machine drive power (MDP*), compaction meter value (CMV), and change in elevation (ΔElevation)) obtained on the east lane for six roller passes are shown in Figure 4.

The MDP alues reported on this project are shown as MDP*. A detailed explanation of MDP* is provided in the Phase I final eport.

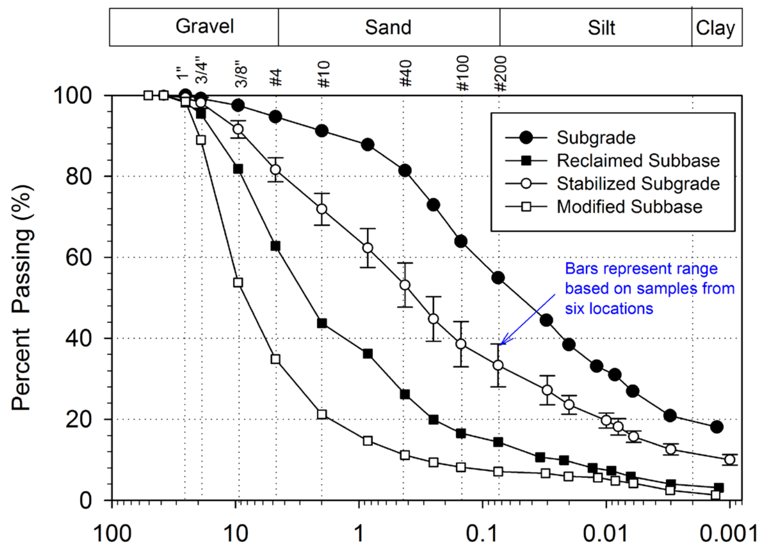

Figure 3. Grain-size distribution curves for subgrade, reclaimed subbase, mechanically-stabilized subgrade, and modified subbase material

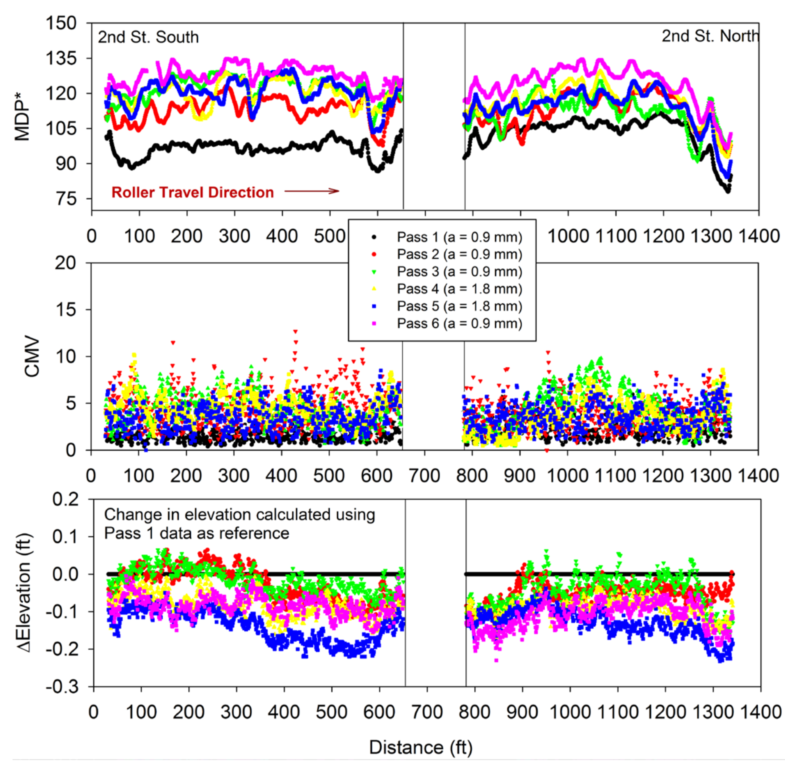

Figure 4. Plots of MDP (top), CMV (middle), and elevation data (bottom) from the RICM roller during compaction of the mechanically-stabilized layer*

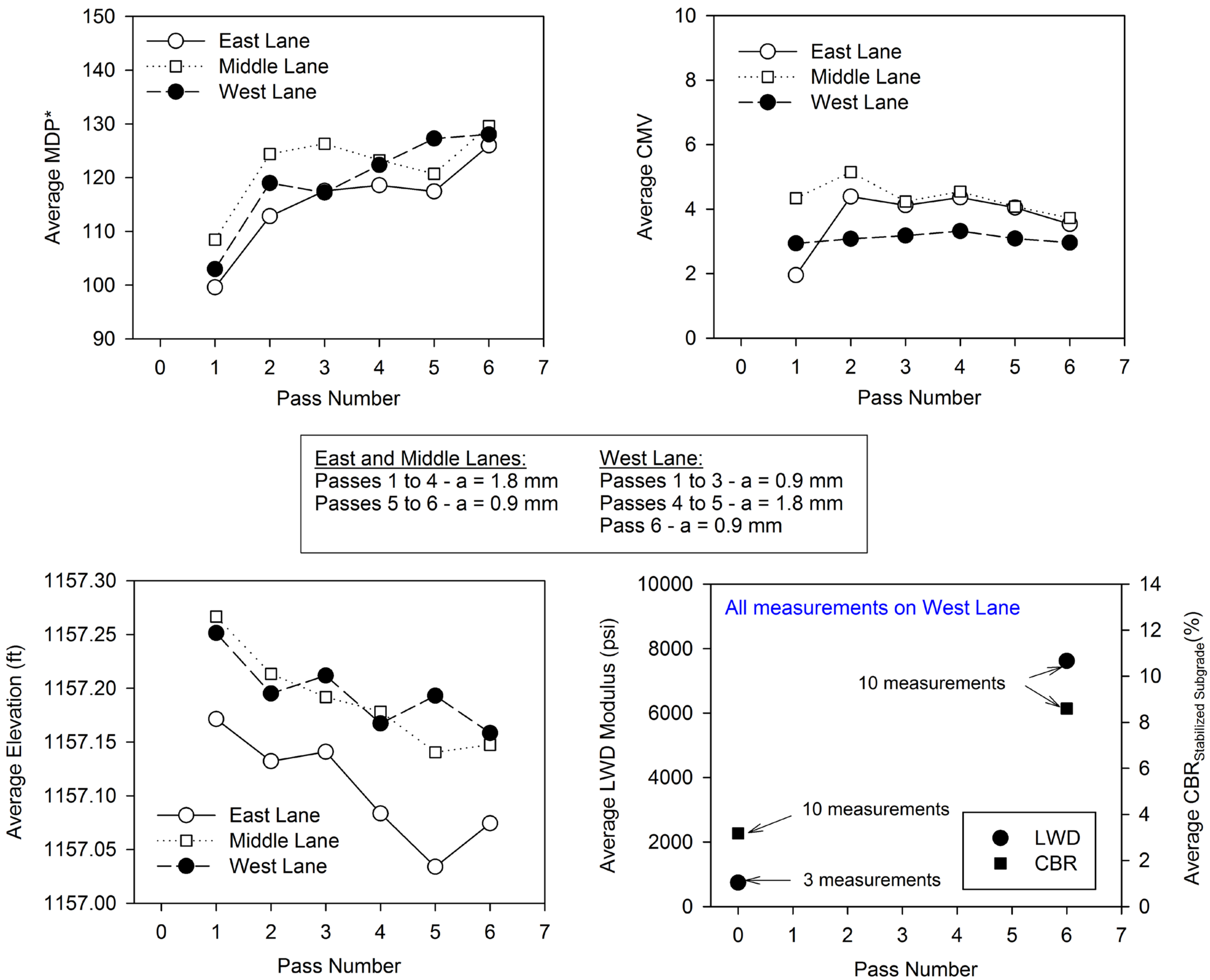

Figure 5. Change in average MDP, CMV, elevation, LWD modulus, and CBR with increasing passes on the mechanically-stabilized layer*

The change in ele ation was calculated using pass 1 elevation data as a reference. Change in average (per pass) MDP*, CMV, and elevation with increasing passes are shown in Figure 5. Average LWD modulus (based on 10 measurements) and CBR (based on 3 measurements) of the stabilized layer before and after compaction are also shown in Figure 5.

MDP* results indicate that the measurements were repeatable and generally increased with compaction passes. CMV values were low (< 10) and did not change considerably with increasing passes. Elevation values generally showed a decreasing trend with increasing passes.

DCP-CBR and cumulative blow profiles f om one test location each in the 2nd St. North and South test sections are shown in Figures 6 and 7, respectively. Test results are provided from May 2012 (before construction), July 2012 (shortly after construction), October 2012 (three months after construction), and April and May 2013 (during and after the spring thaw).

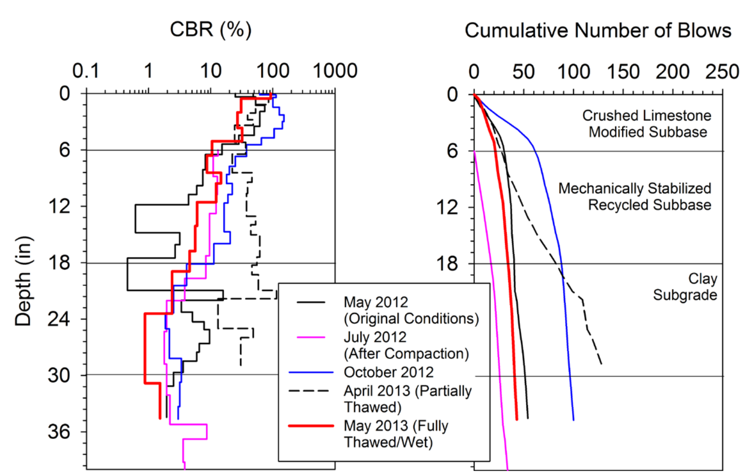

Figure 6. DCP-CBR and cumulative DCP blows profiles for 2nd St. North test section

Average CBR values in the modified subbase, mechanically stabilized subgrade, and unstabilized subgrade layers at diffe ent testing times are shown in Figure 8. Likewise, average surface FWD modulus values are shown in Figure 9.

Results indicate that the CBR of the modified subbase la er and the FWD modulus at the surface decreased considerably during April 2013 testing compared to the values obtained after construction in July and October 2012. However, the CBR values (> 30 on average) of the mechanically-stabilized subgrade layer were higher in April 2013 than the values obtained during and after construction (~ 15 in October 2012). These esults suggest that, although the modified subbase la er was thawed in April 2013, the underlying layers were not fully thawed.

Tests conducted in May 2013 showed the lowest CBR values for all layers. In May 2013, the average CBR (8.6) of the stabilized subgrade layer was about 2.5 times greater than the average CBR (3.4) of the underlying unstabilized subgrade layer.

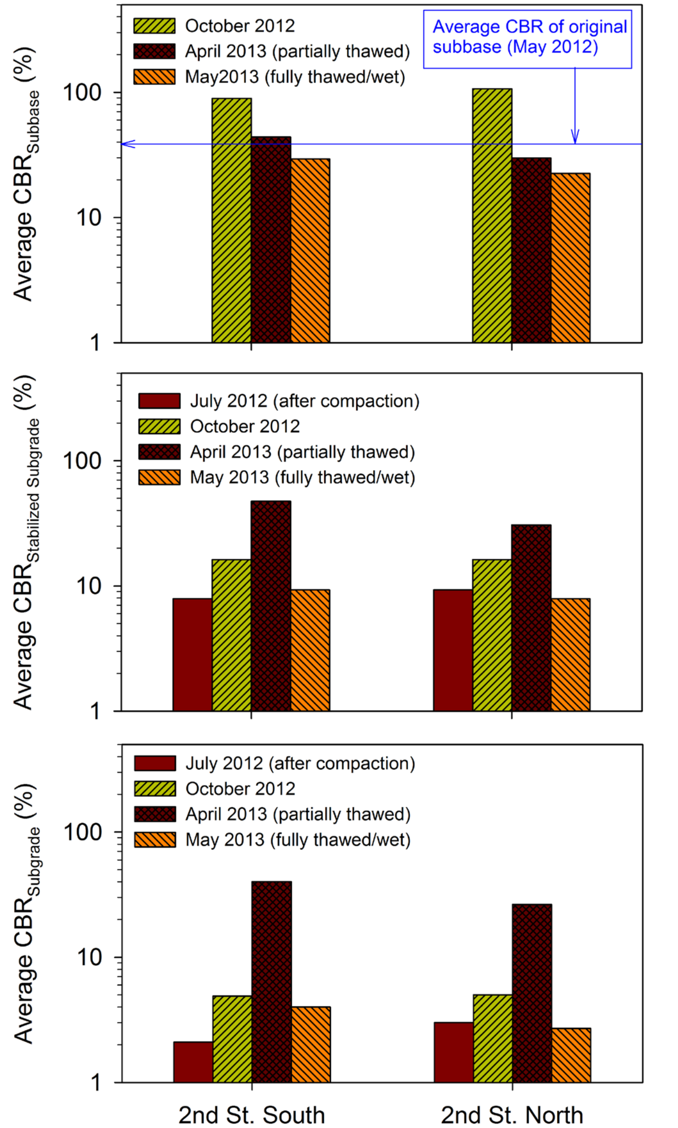

Figure 8. Average CBR (based on 3 to 5 tests) of subbase, mechanically-stabilized layer, and unstabilized subgrade layers on 2nd St. South and North test sections

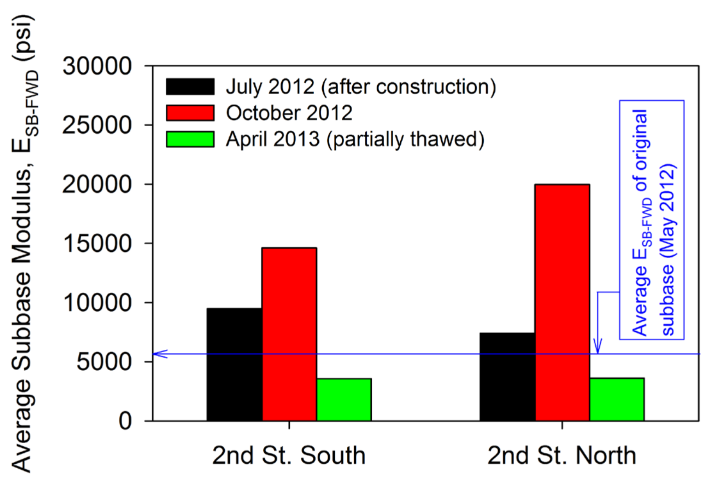

Figure 9. Average FWD subbase modulus (based on 10 tests) on 2nd St. South and North test sections

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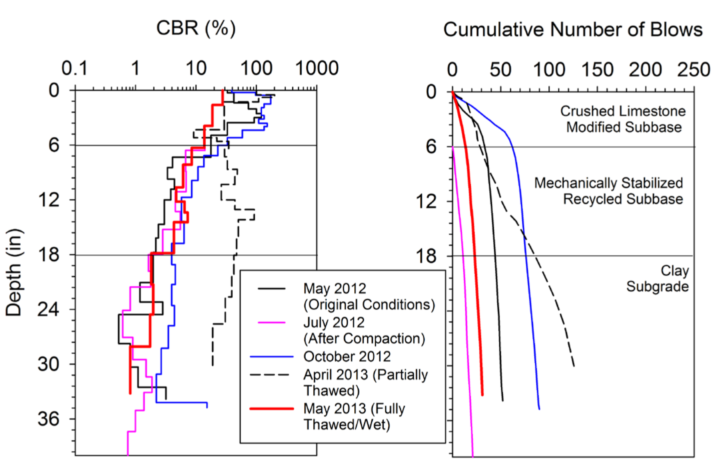

Figure 7. DCP-CBR and cumulative DCP blows profiles for 2nd St. South test section