Central Iowa Expo Pavement Test Sections | TECH BRIEF | December 2013

Geocell Reinforcement of Subbase

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

SPONSORS
Iowa Department of Transportation
Federal Highway Administration

RESEARCH TEAM
David J. White, PhD, PE
Director, Center for Earthworks Engineering Research
Associate Professor
515-294-1463, djwhite@iastate.edu

Pavana K. R. Vennapusa, PhD, PE
Assistant Director, Center for Earthworks Engineering Research
Research Assistant Professor
515-294-2395, pavanv@iastate.edu

Peter Becker
Research Assistant

Christianna White, PhD
Technical Editor

RESEARCH PARTNERS
Iowa Department of Transportation
Central Iowa Expo
Boone County, Iowa Engineer
Foth Engineering Alliance
JB Holland Construction, Inc.
Center for Earthworks Engineering Research

IOWA DOT CONTACT
Mark Dunn, PE
Operations Research Engineer
Office of Research & Analytics
Iowa Department of Transportation
515-239-1447, mark.dunn@dot.iowa.gov

MORE INFORMATION
http://www.ceer.iastate.edu

CENTER FOR
CEER
EARTHWORKS ENGINEERING
RESEARCH

IOWA STATE UNIVERSITY
Institute for Transportation

The Iowa 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 project 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 measurement 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 provides an overview of in situ test results and key findings from two test sections constructed using geocell confinement in the subbase layer using 6 in. and 4 in. geocells.

Background

Geocells are three-dimensional, honeycomb-shaped soil-reinforcing geosynthetics composed of polymeric materials and are primarily used for confinement of granular material. Geocells are placed at grade, in-filled with granular material, and compacted. The cellular structures of the geocells provide lateral and vertical confinement and tensioned membrane effect, thereby increasing the bearing capacity and providing a wider stress distribution (Rea and Mitchell 1978). As a result, rutting or permanent deformations under traffic loading can be reduced. Typically, the geocell-base/subbase system is underlain by a geotextile to separate the in-filled base/subbase material from the subgrade.

The U.S. Army Corps of Engineers first studied the use of geocells to reinforce unpaved roads with poorly-graded sand soils in the 1970s (Webster 1979). Yuu et al. (2008) and Pokharel (2010) summarized previous experimental

Figure 1. Installation of 6 in. geocells over non-woven geotextile placed on subgrade

(laboratory and field) and analytical studies conducted using geocells. Some key aspects of geocell reinforcement that have been studied include: influence of geometric ratio (i.e., height to diameter) of geocell, failure mechanisms, properties of geocell, effectiveness of geocell, loading area, position, and type, infill density, and type and size of geocell (Pokharel 2010).

A design methodology to estimate required base layer thickness over unreinforced or geosynthetic-reinforced layers was proposed by Giroud and Han (2004). This design methodology was extended for geocell reinforcement by Pokharel (2010).

Description of Test Sections and In Situ Testing

In the present study, test sections were built to evaluate the constructability and long-term performance of 6 in. and 4 in. high geocell sections filled with crushed limestone-modified subbase. In situ engineering properties (i.e., strength and stiffness) are being monitored over time. The geocells used in this study are made of virgin, non-thermally degraded, high-density polyethylene with a perforated cell design.

The test sections originally consisted of a thin chipseal coat and an 8 in. granular subbase at the surface. The granular subbase material was excavated down to the subgrade level. The existing subgrade material is classified as CL or A-6(5).

Test sections were constructed with 4 in. high geocells on 3rd St. North and with 6 in. high geocells on 3rd St. South. A non-woven geotextile was placed at the interface of the geocell-reinforced base layer and the subgrade to act as a separation barrier (Figure 1). The geocell strips were stretched by staking the edges with short pieces of reinforcing bars.

Adjacent geocell strips were initially attached using 5 in. long staples or zip ties. This approached resulted in variability in the geocell opening widths and relatively slow speed of construction. Later, a pneumatic hog ring tool was used to staple adjacent geocell strips, which expedited the construction process and helped achieve more uniform geocell openings.

After the geocells were installed, crushed limestone subbase material was placed with a skid steer (Figure 2) and compacted using a smooth drum vibratory roller. The crushed limestone subbase layer was classified as GP-GM or A-1-a (7% fines content). The design subbase layer thickness was 6 in. in the 4 in. geocell section and about 7 in. in the 6 in. geocell section. The surface of the 6 in. geocell subbase layer after spring thaw in April 2013 is shown in Figure 3.

Bid data from six contractors indicated a median installed unit price of \$8.29/yd^2 with a range of \$6.04/yd^2 to \$12.24/yd^2 for installing 4 in. geocell and a median price of \$11.13/yd^2 with a range of \$8.63/yd^2 to \$15.13/yd^2 for installing 6 in. geocell.

In situ testing included testing the foundation layers prior to construction (May 2012), about three months after construction (October 2012), and immediately after the spring thaw (April 2013). In situ testing involved light weight deflectometer (LWD), dynamic cone penetrometer (DCP), falling weight deflectometer (FWD), and roller-integrated compaction monitoring (RICM). Results from only the DCP and FWD tests are presented here. All test results are presented in the Phase I final report.

In Situ Test Results and Key Findings

DCP-California bearing ratio (CBR) and cumulative blow profiles with depths from the 4 in. and 6 in. geocell sections before construction, three months after construction in October 2012, and after spring thaw in April and May 2013 are shown in Figures 4 and 5.

Bar charts of average FWD subbase modulus values and subbase CBR values of the two test sections are shown in Figure 6. The average FWD values were calculated based on 10 tests per section and CBR values were calculated based on three tests per section.

CBR and FWD modulus of the geocell-reinforced subbase layers achieved peak values about three months after construction. On average, subbase CBR values in the 6 in. geocell section were higher (~90) than in the 4 in. geocell section (~50). The subbase CBR values were higher than the original in-place subbase layer CBR (ranged from 20 to 40 from May 2012 testing). On average, FWD moduli of the geocell-reinforced subbase layer were similar in both sections. The FWD values on the geocell-reinforced subbase layers were similar to the values on the original in-place subbase layer.

Figure 2. Placement of crushed limestone base in 4 in. geocells

Testing during the thawing period (April and May 2013) yielded the lowest CBR and FWD modulus values. Additional monitoring is warranted to investigate changes in strength and stiffness with time.

References

Giroud, J. P., and Han, J. (2004). “Design method for geogrid-reinforced unpaved roads. I. Development of design method.” *Journal of Geotechnical and Geoenvironmental Engineering*, 130 (8), 775-786.

Pokharel, S. K. (2010). Experimental study on geocell-reinforced bases under static and dynamic loading. PhD dissertation, Department of Civil, Environmental, and Architectural Engineering, University of Kansas, Kansas.

Rea, C., and Mitchell, J. K. (1978). Sand reinforcement using paper grid cells. Proceedings, ASCE Spring Convention and Exhibit, Symposium on Earth Reinforcement, Pittsburg, Pennsylvania.

Figure 3. Surface of 6 in. geocells after spring thaw (April 2013)

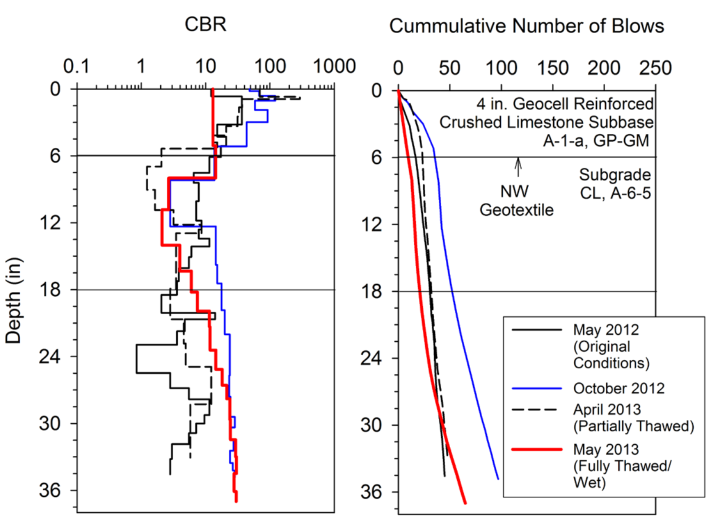

Figure 4. DCP-CBR and cumulative DCP blows with depth profiles from tests conducted on 3rd St. North before construction and at two times after construction of 4 in. geocell-reinforced subbase

Webster, S. L. (1979). *Investigation of beach sand trafficability enhancement using sandgrid confinement and membrane reinforcement concepts*. Report GL-79-20 (1), U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

Yuu, J., Han, J., Rosen, A., Parsons, R. L., and Leshchinsky, D. (2008). Technical review of geocell-reinforced base courses over weak subgrade. Proceedings, First Pan American Geosynthetics Conference & Exhibition, Cancún, Mexico.

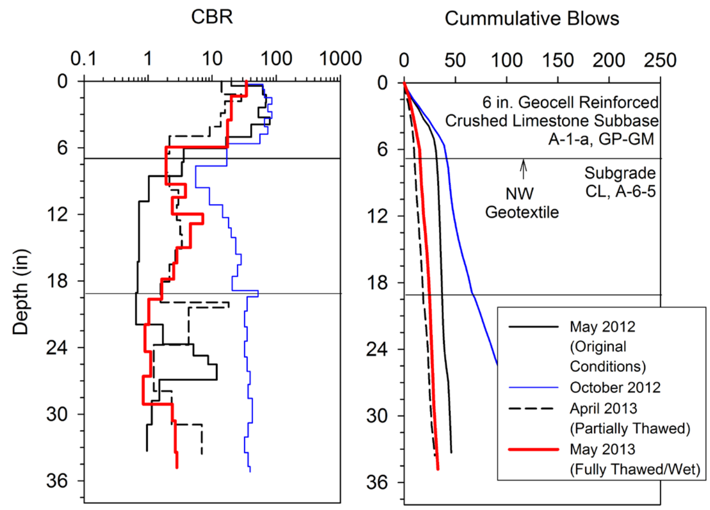

Figure 5. DCP-CBR and cumulative DCP blows with depth profiles from tests conducted on 3rd St. South before construction and at two times after construction of 6 in. geocell-reinforced subbase

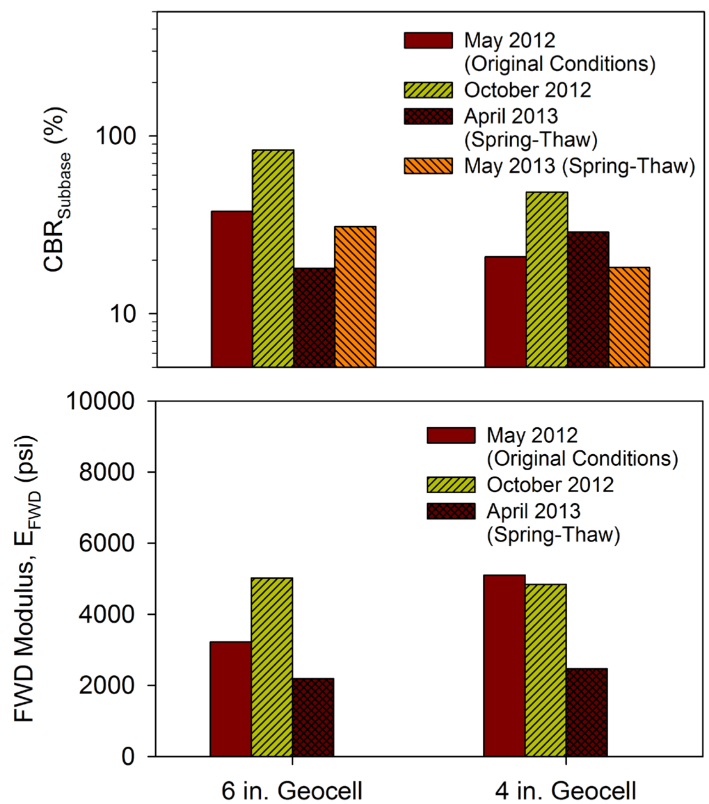

Figure 6. Average CBR of subbase and FWD modulus values before construction, three months after construction, and after spring thaw in 6 in. and 4 in. geocell-reinforced subbase sections