PROJECT SUMMARY

Texas Department of Transportation

# 0-6833: Use of Geocell in Pavement Design

## Background

Geocells are robust, lightweight, three-dimensional fabricated systems that are expandable on-site to form a honeycomb-like structure. Geocells have been intermittently used in roads; they provide lateral reinforcement that increases the bearing capacity of the subbase and subgrade pavement layers.

The following are the objectives of this project:

i. To evaluate the existing pavement design methods with geocell reinforcement
ii. Develop an experimental design to characterize geocells' improved support mechanisms.
iii. Develop a finite element model to replicate the laboratory experiment set up.
iv. Conduct experimental and statistical analyses of the collected laboratory data.
v. Develop a design system for future pavement construction using geocells.
vi. Perform life-cycle cost analysis with pavements using the geocell reinforced layer.
vii. Develop specifications and construction steps for future highway construction using geocells.

## What the Researchers Did

To achieve the objectives mentioned above, the researcher performed the following tasks

| Tasks | Objectives |
|---|---|
| Finite element modeling (FEA) and analysis of results | Finite element models with and without geocell are developed and calibrated with the laboratory results. |
| Selection of Material, Experiment Design, and Laboratory Evaluation | Two subgrades and three base materials from various locations in Texas were collected. The testing mold was fabricated. Electronic devices such as strain gauges and pressure cells were used to measure the responses of the samples during testing. |
| Statistical Analysis | The main idea of this task is to demonstrate the development of a mathematical model for capturing the geocell reinforced layer benefit over the unreinforced layer using multi-linear regression. |
| Critical Evaluation of Existing Design Methods | This task provides information on existing pavement design methods for low-volume roads with the incorporation of geocell layers. |
| Validation of Proposed Design Method | In this task, input parameters for designing low-volume roads in Texas with geocell reinforced layers are provided. Cross-validation techniques are used for validating the proposed method. |
| Cost Analysis | The economic feasibility of geocell in pavement construction is evaluated in this task. |
| Practitioners Guidelines | The main idea of this task is to guide the practitioners in material selection, design, construction, and safety of pavements with geocell layers. |
| Results of Site Instrumentation | This task involves instrumenting the pavements constructed with a geocell reinforced base and no geocell for measuring the responses under traffic load. |

## What They Found

1. This report identified four parameters influencing the performance: cover thickness (layer over geocell) and quality of cover material; geocell layer thickness; infill material (in geocell) modulus, and subgrade modulus.
2. Finite Element Method (FEM) analysis shows:
   i. 4" and 6" geocell heights provide the most benefit of using geocells.
   ii. Also, the benefit of geocell reduces with an increase in base modulus (same material for infill and cover).
3. Laboratory Evaluation results indicated that the pressure cells placed beneath the loading plate and one foot away showed that the stresses on the

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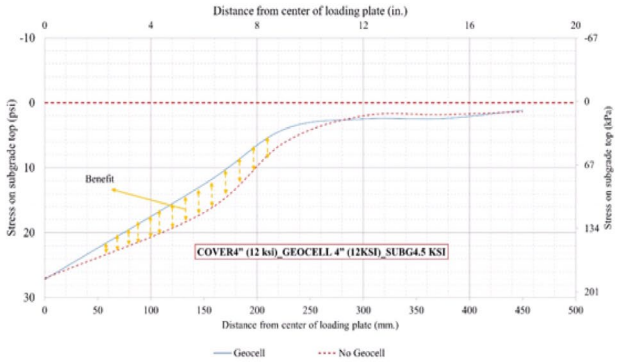
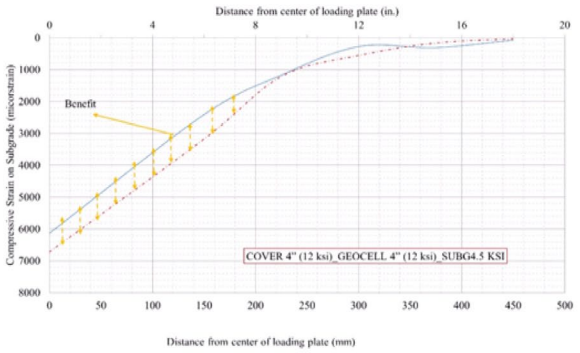
**Project Completed:**
11-30-2018




Stress Distribution




Strain Distribution

subgrade are reduced at these locations significantly by placing a geocell reinforced layer.

4. PRESTO GEOSYSTEM (2008) and Pokharel (2010) design methods for low volume roads revealed a significant benefit of using geocell reinforcement for pavements with a weak subgrade.

5. Summary of models used for Cross-validation Techniques is shown in the figure below.

## What This Means

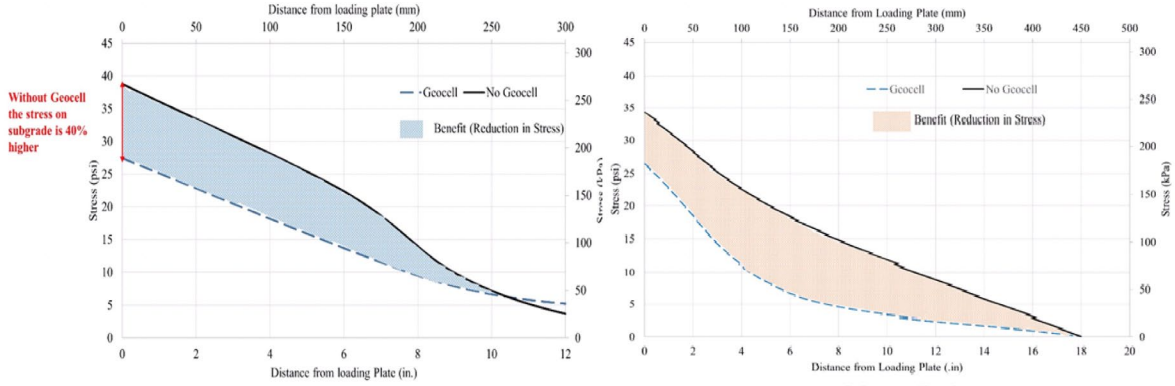
The recommendations of this study are as follows:

1. This study recommends the use of geocell when low-quality material is present.

2. Cover thickness (layer over geocell) and quality of cover material; geocell layer thickness; infill material (in geocell) modulus, and subgrade modulus are four factors that influence the performance of geocell reinforced pavements. This study recommends:
   a. Cover thickness higher than 3".
   b. Geocell is more efficient with lower modulus base materials.
   c. 4" and 6" geocell heights provide the benefit of using geocells.

3. From laboratory testing and FEA analysis, it is revealed that higher quality (high modulus) infill reduces the benefit of Geocell use.

| Type of Modelling | Coefficients | | | | R-Square | paired t-test * | | | | Pearson correlation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Intercept | Geocell Height | Infill Modulus | Cover Thickness | | Significance (p-value) | Hypothesis | 95% Confidence Levels | | |
| | | | | | | | | Lower | Upper | |
| Without Cross Validation (CV) | -9.15 | 4.46 | -0.514 | 2.196 | 0.62 | Na | Na | Na | Na | Na |
| LOOV - CV | -7.69 | 4.65 | -0.50 | 1.74 | 0.62 | 0.12 | alternative | -0.66 | 4.81 | 0.82 |
| KK-FOLD CV | -8.98 | 4.56 | -0.50 | 2.09 | 0.60 | 0.19 | alternative | -0.90 | 3.89 | 0.85 |
| Bootstrapping CV | -8.85 | 4.64 | -0.53 | 1.93 | 0.56 | 0.16 | alternative | -3.87 | 0.75 | 0.88 |




FEM Results

Laboratory Results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Keyword: Research