



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.

Tasks	Objectives
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

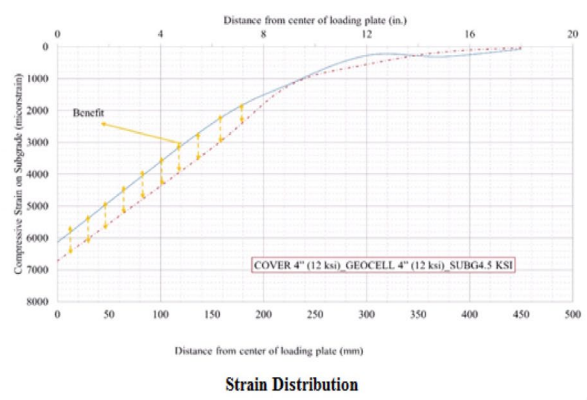
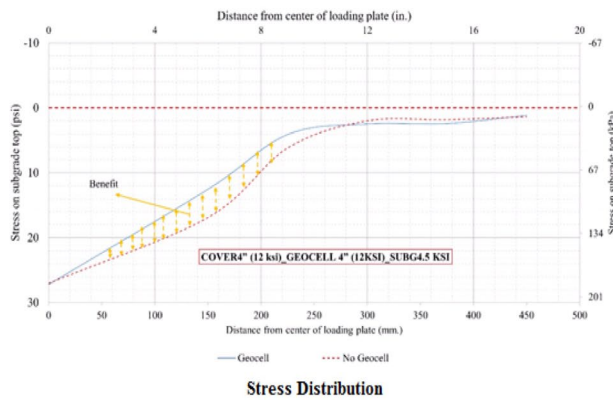
1. This report identified four parameters influencing the performance: cover thickness (layer over geocell) and quality of cover material; geocell layer thickness; infill material (in geocell) modulus, and subgrade modulus.
2. Finite Element Method (FEM) analysis shows:
 - i. 4" and 6" geocell heights 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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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:

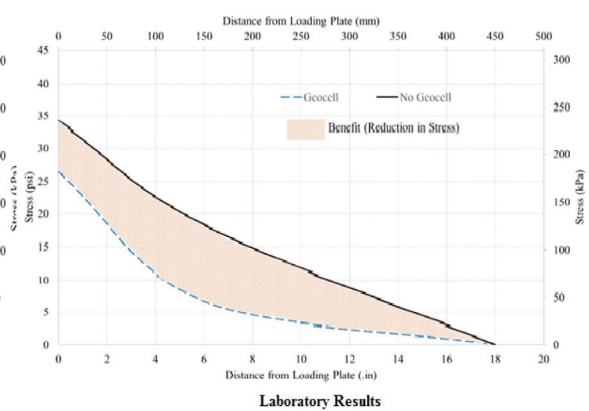
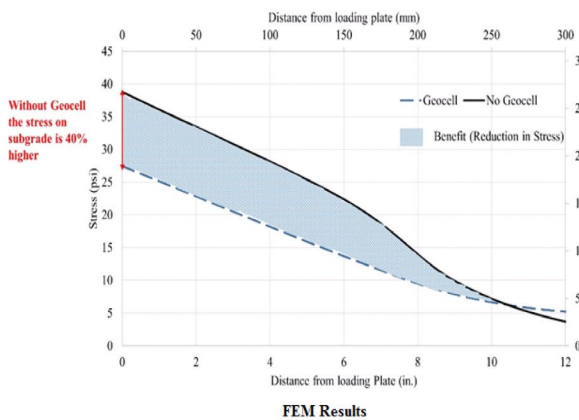
1. This study recommends the use of geocell when low-quality material is present.

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:

- Cover thickness higher than 3".
- Geocell is more efficient with lower modulus base materials.
- 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



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