The University of Texas at Arlington

Project Summary Report 0-4573-S

The Effects of Using Compost as a Preventive Measure to Mitigate Shoulder Cracking: Laboratory and Field Studies — SUMMARY REPORT

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Desiccation cracks in expansive clayey soils are generally formed during the drying conditions in summer environments. These cracks often appear on unpaved shoulder subgrades where they are vulnerable to drying due to direct exposure from high temperature conditions. These cracks, if not controlled, will eventually propagate under and upward through the paved shoulder as seen in Figure 1.

These cracks allow surface runoff water infiltration into subsoil layers and eventually weaken both the base and subgrade materials. Both softening and volume changes of the underlying expansive cohesive soils could further damage pavements and deteriorate the structural performance of pavements. Surficial cracks in both the longitudinal and transverse directions of pavements are testimonies to pavement damage and they can be seen in Figure 2. Hence, protection and maintenance of unpaved shoulder subsoils are key elements to mitigate the cracking on the roadways and related paved structures.

Effective remediation methods must be immediately applied to prevent desiccation cracking of expansive subsoils situated in unpaved shoulders. Several chemical and mechanical treatment methods have been used to stabilize expansive subgrade soils. However, these methods have their own limitations and restrictions. Some are expensive, some are less effective, and some are not suitable in sulfate-rich soils.

Figure 1: Shoulder Cracking of SH 108 Unpaved Shoulders (Transverse Cracks)

Figure 2: Longitudinal and Transverse Cracks on Paved Shoulders

Compost materials, given their moisture affinity (hydrophilic), low permeability, and fibrous characteristics, are expected to reduce swell and, more importantly, shrinkage behaviors of underlying natural subsoils by encapsulating and reinforcing them. As a result, cracking from soil movements can be mitigated.

In this research, an attempt was made for the first time to study the potential benefits of compost amendments to mitigate cracking in expansive subgrades. Successful use of this research would result in two major benefits: one is to reduce pavement maintenance problems caused by the expansive subsoil movements, and the other is to reduce the landfilling of the compost source materials, which are predominantly solid waste materials. This study has focused on two types of inexpensive recycled composts, Biosolids Compost (BSC) and Dairy Manure Compost (DMC), to stabilize topsoils in adjoining shoulders to mitigate shoulder cracking. Both source waste materials are heavily produced in the state of Texas and hence any application of these materials in compost form would reduce waste generation and enhance waste recycling.

What We Did …

The work undertaken for this research in the past two years includes the following tasks:

- Literature Review: Researchers conducted a comprehensive literature review on various compost source materials and their applications in highways including erosion control, landscaping, and vegetation growth.
- Experimental Investigations on Composts and Compost Manufactured Topsoils (CMT): Two compost materials, BSC and DMC, were used for topsoil amendments at two different proportions for each type of compost. Hence, a total of four CMT materials were evaluated in this research. Expansive clay (PI=28) from Stephenville, Texas, was sampled and used as the topsoil. Both the Control Soil and CMTs were subjected to a multitude of geotechnical characterization tests including Atterberg Limits, standard Proctor compaction, free swell, linear shrinkage, and direct shear strength tests. Strength, swell and shrinkage tests were performed at two different compaction moisture contents.
- Ranking Analysis: Laboratory test results were analyzed based on soil property enhancements. The final outcome of this analysis was the selection of compaction moisture contents for each CMT material for field evaluations.
- Field Test Plot Construction: Design and compaction specifications for the construction of CMT plots were developed. These specifications were followed in the construction of sixteen CMT covered test plots and one control test plot with no CMT cover. These plots were constructed on SH 108 near Stephenville, Texas. Each plot had a CMT of certain treatment width (5 or 10 ft) and treatment depth (2 or 4 in.).
- Field Monitoring Studies: Several different field monitoring tasks as shown in Figure 3 were designed and executed to address shrinkage cracking patterns of subsoils. Other concerns including erosion potentials of CMTs and leachability characteristics of runoff from test plots were also addressed.
- Data Analysis: Statistical comparison studies were used to analyze the variations between field data collected from CMT plots and the Control Soil plot. This analysis was used to evaluate the effectiveness of compost amendments to mitigate subsoil cracking. Also, the erodability of the CMTs in field conditions, potential to establish revegetation on compacted CMTs, and runoff qualities of the leachate collected from test plots were addressed.
- Deliverables: Research deliverables including two research reports, design and compaction specifications for CMTs, and a project summary report were submitted.

What We Found …

Based on the research performed in the past two years, the following major findings are established:

- Comparison analyses of field data (shown in Table 1) indicated that the BSC-amended CMTs provided low moisture and temperature variations in field when compared to the Control Soil and the DMC-amended CMTs. No new paved shoulder cracks were detected adjacent to the majority of the BSC plots during the monitoring period, which led to the major observation that BSC materials used in this research reduced shrinkage cracking in subsoils and hence mitigated cracking in the adjacent pavement sections. The DMC materials showed no reductions in shrinkage cracking and as a result, new cracks in paved shoulders were detected. Shrinkage cracking in DMC plots was primarily attributed to low amounts of organic fibrous material present in these DMCs. Enhancements of organic material in DMCs are expected to improve the performance of these composts in field application.
- BSC plots had approximately 20% less erosion than in the Control Plot. The DMC plots, due to low fibrous materials, experienced more erosion (more than 50%) than the Control Plot.
- Certain pollutant characteristics from the surface runoff collected from the DMC plots were slightly higher than the benchmark values established by the U.S. Environmental Protection Agency. This is attributed to high proportions of dairy manure used in the dairy manure CMTs, location of runoff sampling points, and possible concentration effects due to the sampling durations.
- Due to high organic content and low compaction density in BSC materials, vegetation was greater in the BSC plots and lesser in the DMC plots. This implies that landscaping will be enhanced when BSCs are used for soil amendments.

The Researchers Recommend …

Biosolids Compost amendments showed the potential to reduce shrinkage cracking of the expansive soils by encapsulating and reinforcing them. This amendment will not only reduce the pavement cracking and pavement maintenance costs, but will also enhance recycling efforts by using Biosolids Composts in a large-scale application of topsoil treatment in highway projects. Dairy Manure Compost amendments, though providing only moderate improvements, can be enhanced by adding fibrous material during the composting process. Further field studies are recommended on different soil conditions representing various regions in the state of Texas with different compost sources as CMT materials.

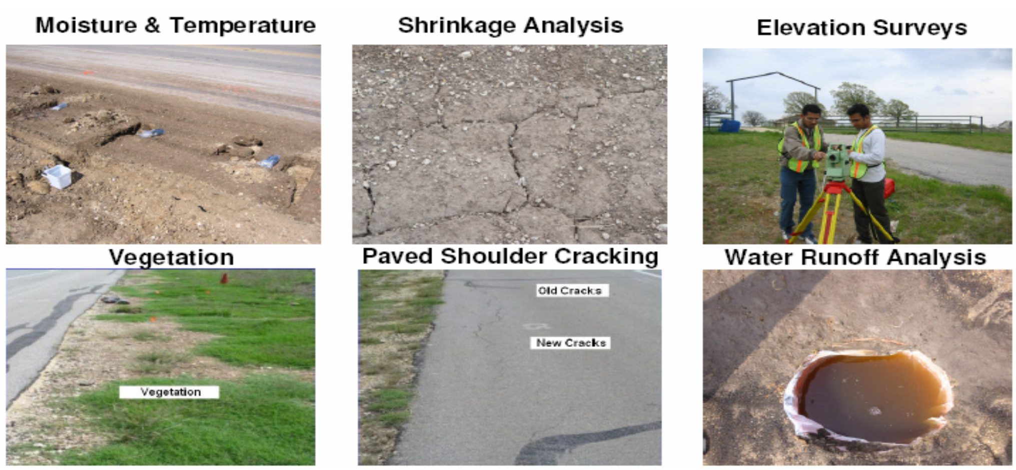

Figure 3: Field Monitoring Tasks

Table 1: Final recommendation of CMTs

Plot Type	Percent Compost (%)	Width (ft)	Depth (in)	Enhancement?						Recommendation
				Shrinkage Cracking	Temp Variation	Moisture Variation	Erosion	Paved Shoulder Cracking	Vegetation	
Dairy Manure Compost (DMC) Plots	75	5	2	-	x	✓	x	x	x	x
	75	5	4	x	✓	-	x	✓	✓	x
	75	10	2	x	x	x	x	x	-	x
	75	10	4	x	✓	x	x	✓	-	x
	100	5	2	x	✓	✓	x	x	x	x
	100	5	4	x	✓	✓	x	✓	✓	x
	100	10	2	x	✓	x	x	✓	x	x
	100	10	4	x	✓	✓	x	✓	-	x
Biosolids Compost (BSC) Plots	20	5	2	✓	✓	✓	✓	x	✓	x
	20	5	4	✓	x	x	✓	✓	✓	✓
	20	10	2	✓	✓	x	✓	✓	✓	✓
	20	10	4	✓	✓	✓	✓	✓	✓	✓
	30	5	2	-	x	x	✓	x	✓	x
	30	5	4	✓	x	x	✓	x	✓	x
	30	10	2	✓	✓	✓	✓	✓	✓	✓
	30	10	4	✓	✓	✓	✓	✓	✓	✓

Note: ✓- Effective; x – Not Effective; - - No change;

For More Details….

The research is documented in the following reports:
0-4573-1: The Effects of Using Compost as a Preventive Measure to Mitigate Shoulder Cracking
0-4573-2: The Effects of Using Compost as a Preventive Measure to Mitigate Shoulder Cracking: Laboratory and Field Studies

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Your involvement is welcome!

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