Treatment of Soils with Compost to Mitigate Pavement Cracking

Texas Tests and Applies Stabilization Method

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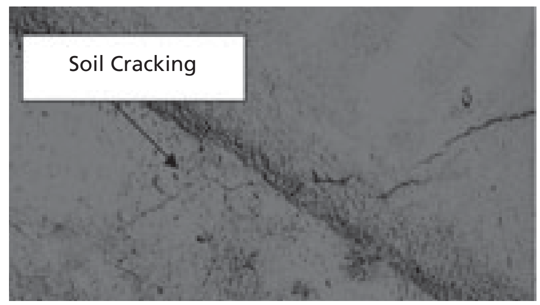
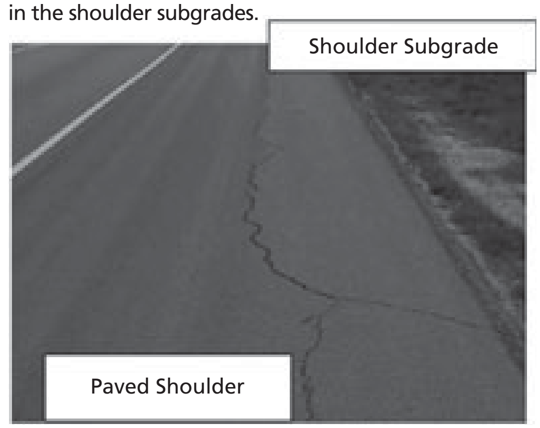
Cracks form in swelling soils in Texas generally during the dry conditions in summer and winter. The surface cracks appear when the soils dry under high temperatures or high rates of evaporation, or both. If these adverse conditions prevail for extended periods, the soil adjacent to pavement shoulders dries and cracks (see photo, this page).



Soil cracking on unpaved shoulder subgrade, extending to paved flexible shoulders (transverse cracks), Texas State Highway 108. *(Below:)* Longitudinal and transverse cracks on paved shoulders; the cracks started in the shoulder subgrades.

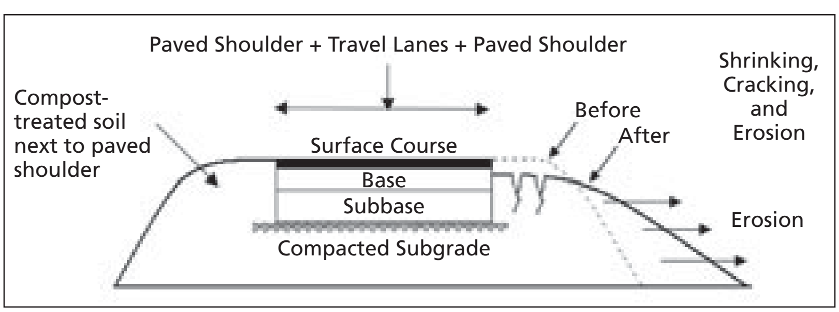


Problem

Uncontrolled cracks in the soil extend to the subgrades beneath the paved shoulders and ultimately under the pavements. The cracked subgrades lose strength when moisture infiltrates. As a result, paved shoulders and pavements over the softened subgrades undergo differential movement, producing longitudinal and transverse cracks (see photo, this page). The erosion of the subgrade also may accelerate cracking (Figure 1).

Several chemical treatment methods, including traditional cement and lime additives, have been used to stabilize swelling soils. These methods are expensive for treating soil adjacent to paved shoulders, however, and are not suitable if the swelling soils contain sulfates. The normal practice at the Texas Department of Transportation (DOT) is to seal cracks on paved shoulders and travel lanes each year; the crack-sealing program costs approximately $10 million annually. A less expensive stabilization technique therefore is needed to mitigate the cracking caused by the movements of soil next to paved shoulders, to mitigate cracks in paved shoulders and pavement.

FIGURE 1 Schematic Showing Subgrade Cracking and Erosion That Could Lead to Pavement Cracking (not drawn to scale).



Solution

Compost consists of disinfected and stable decomposed biosolids, manures, yard wastes, and waste food processed into a useful product free of odors and pathogens. The United States generates 8 million tons of biosolids and 32 million tons of manures annually; almosts 40 percent of biosolids and approximately 50 percent of manures are disposed in landfills. Some manures can pollute waterways.

Compost has an affinity for water, low permeability, and fibrous characteristics. Compost has potential, therefore, to reduce the swell and shrinkage behavior of natural soils.

A Texas DOT–sponsored research project investigated the potential benefit of treating swelling soils to mitigate cracking. In 2003, the engineering properties of biosolids compost (BSC), dairy manure compost (DMC), compost-treated or manufactured topsoils (CMT), and swelling soil from Stephenville, Texas, were analyzed to determine the compost dosages for field treatments. Design- and compaction-related construction specifications were developed and were used to construct 16 CMT plots by mixing BSC and DMC with the soil and then compacting. One control plot also was constructed.

The plots were constructed on Texas State Highway 108, near Stephenville, in 2004. The test sections differed in the percentage, width, depth, and type of compost treatment. Field monitoring determined the extent and pattern of the cracking, the erosion potentials of CMTs, and the characteristics of the leachate in the runoff from the test plots.

Field data were collected for two years and were analyzed with statistical comparison techniques. The results are as follows:

- BSC-amended CMTs had lower moisture and temperature variations than either the control or DMC-amended CMT plots.
- No new cracks were observed on the paved shoulders adjacent to seven out of eight BSC plots, while the DMC materials did not reduce the cracking but developed new cracks in paved shoulders (see photo comparison, this page).
- Vegetation did better in the BSC plots than in the DMC and control plots.
- BSC plots experienced approximately 20 percent less erosion than the control plot. The DMC plots showed 50 percent more erosion than the control plot.
- Concentrations of total suspended solids and biochemical oxygen demand in leachate from the DMC and BSC plots—100 parts per million (ppm) and 30 ppm, respectively—were less than the limits established by the U.S. Environmental Protection Agency (EPA). Chemical oxygen demand and total nitrogen values exceeded the EPA threshold values of 120 ppm and 2 ppm, respectively, in leachate from the DMC plots only. Therefore the recommendation was to reduce the percentage amount of dairy manure additions to soils.

Because of its high amounts of organic fibrous material, BSC encapsulated and reinforced the soil particles and reduced the cracking of the soil. The wood chips acted as soil connectors, holding the soil intact longer during periods of drought. DMC has low amounts of organic fibrous material, however, and was not effective in reducing cracking. Therefore DMC performance may be improved by adding fibrous material during the composting process.

Applications

Texas DOT implemented the research findings in Corpus Christi, Lubbock, Bryan, Tyler, and Yoakum Districts in 2005. Eight different compost types were used, and in all but Bryan District, the findings agreed with those from the Stephenville project. In Bryan District, the lack of vegetation allowed the erosion of the CMTs within a short time after construction.

Benefits

New cracked areas on the paved shoulder and the pavement next to BSC-treated swelling soils developed on average less than 50 percent as often as those observed for the control section. Moisture and temperature data, elevation surveys, and visual observations indicated that BSC treatment has mitigated the cracking of soil and pavement. Reapplication of the BSC may be required once every 7 to 10 years; in contrast, crack sealing typically must be applied every 1 to 3 years.

Like most state DOTs, Texas DOT keeps comprehensive records of maintenance costs but does not have detailed records that would show the cost of maintenance related to pavement failure caused by subgrade heaving. A few Texas DOT districts are now conducting life-cycle cost analysis (LCA), which requires more detailed tracking of maintenance repair costs, to compare the life of the compost treatment against the crack-sealing method.

Crack sealing in Texas has proved to be costly and ineffective since the materials do not last more than three years, and many fail after only one year. A pavement with considerable cracking from subsoil movements will deteriorate faster and will develop ruts and alligator cracks. An LCA comparing the compost treatment of soils versus crack sealing will provide better insight into the long-term performance of the two methods.

Texas DOT is considering implementation of the BSC stabilization method as a pavement preservation technique on most highway reconstruction and maintenance projects in all 25 districts. The findings of this project are applicable to any area with similar soil and weather conditions.

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(a)

(b)

(c)

Cracks in paved shoulders and vegetation growth on adjacent soil two years after treatment: (a) BSC plot; (b) DMC plot; and (c) control plot.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-2952, e-mail gjayaprakash@nas.edu).