



PUTTING RESEARCH TO WORK

BRIEF

Stabilizing Surficial Slope Failures with Vertical Members

Shallow slope failures along highway embankments in Wisconsin are a common problem, especially for slopes underlain by finer-grained soils. These surficial failures (instabilities that occur within 2 to 4 feet of the embankment surface) typically occur after heavy rain or during spring thaw. They can be triggered by changes in slope geometry, seepage pressure, added surcharge from traffic loads on highway embankments, and increased pore water pressure due to soil saturation. The type of soil and the degree of stratification can also affect the magnitude of slippage or failure.

What's the Problem?

Slope failures are costly to repair and can damage highway infrastructure such as guardrails, shoulders, pavement surfaces, drainage facilities, utility poles and slope landscaping. They can also create dangerous road conditions when debris flows onto the highway.

The responsibility for fixing failed slopes often falls to highway maintenance crews, who usually push the soil back into place and regrade. This often proves to be only a temporary solution, with failure recurring after subsequent rainstorms. Other repair techniques, such as improving drainage, laying geotextile fabrics and bioengineering, have also been used with varying success. Because slope failures are a nuisance and can be expensive to repair, highway engineers are continually looking for more efficient and cost-effective ways to repair them.

Research Objectives and Methodology

WisDOT funded this study to learn more about the relatively new method of using short preformed vertical members made from recycled plastic, wood, steel or concrete to keep repaired soils in place. This method has been implemented in other states, such as Missouri, with good results. Investigators' tasks and objectives included:

- Performing a comprehensive literature search and review regarding the methods of using vertical structural members to stabilize shallow slope failures.
- Providing WisDOT with a state-of-the-practice synthesis of the design, construction, costs and effectiveness of these methods and technologies.
- Performing a comprehensive slope-stability analysis on surficial slope failures over a wide range of Wisconsin soil properties to determine the optimum size, length and spacing of these members for each material type.

Results

The literature search found that other agencies have used prefabricated structural members constructed from steel pipe, timber, plastic lumber and precast concrete to reinforce slope failures. While it is not yet common practice, there is growing interest by highway departments and contractors in this technique.

Based on the literature review and interviews conducted with selected state highway engineers, researchers identified three innovative methods of using vertical members to stabilize surficial slope failures:

- Installing small structural members by conventional methods.
- Installing launched soil nails.
- Installing earth anchoring systems.

Investigators also determined that some of these methods are more cost-effective than conventional repair methods.

Investigator



"Literature review of short-term field performance data found that using closely spaced short structural members such as plastic lumber is an effective remediation method for surficial slope instabilities."

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“This research summarizes the state of the art in using small vertical members to repair surficial slope instabilities. The next step is educating county maintenance personnel and contractors in the use of these methods.”

—Jeffrey Horsfall

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Researchers determined that wood lumber and earth anchors are cost-effective choices for stabilizing surficial slope failures such as this one along WIS 164 in Waukesha County (Fig. 2.3 of the final report).

To further analyze the effectiveness of these methods in Wisconsin, a comprehensive slope-stability analysis was conducted using various Wisconsin soil and slope parameters for both dry and saturated conditions. A surficial slope failure along WIS 164 in Waukesha County was selected for the analysis. The results demonstrated that all three methods were effective in stabilizing the failure. Noted improvements were increased factors of safety and the elimination of the surficial nature of the slope failure.

The researchers concluded:

- The methods that are most promising for stabilizing surficial slope failures in Wisconsin in terms of cost-effectiveness and field performance are the small structural members and the earth anchoring systems.
- Short-term field performance data showed that plastic lumber is an effective remediation method if installed in closely spaced configurations (3-foot spacing).
- Both wood lumber and earth anchors are cost-effective choices.
- Although soil nails were effective, their overall cost was more than four times that of plastic lumber.
- Because this is a relatively new approach, long-term field performance data is not available. Creep of plastic lumber and decay of wood lumber in aggressive environments may limit the effectiveness of these materials over time in stabilizing repaired slopes.

Implementation and Further Research

To evaluate the longer-term performance of these repair methods, WisDOT plans to repair sections of two surficial slope failures (cut slope and embankments) using different structural members, such as plastic lumber and wood. A field monitoring program that includes installing inclinometers, performing visual surveys and collecting climate data will capture and analyze the field performance data. The results will provide WisDOT with the information the department needs to make an informed decision regarding the implementation of these repair methods along Wisconsin highways.

This brief summarizes Project 0092-05-09, “Investigation of Vertical Members to Resist Surficial Slope Instabilities,” produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

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