The Ohio Department of Transportation
Office of Research & Development
Executive Summary Report

Bio-Engineering for Land Stabilization

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Problem

Soil-bioengineering, or simply "bioengineering", is the use of vegetation for slope stabilization. Currently, a large number of slopes near Ohio highways are experiencing stability problems. These failures usually begin as local erosion or shallow mass movements on a slope face, which become progressively worse with time and often eventually threaten the highway. At this time, the slope requires a significant and costly repair using conventional engineering methods, such as slope reconstruction or a retaining structure. Substantial cost savings would be possible if a method were developed to stabilize early small failures before they grow into larger problems. Such a method would be even more attractive if it was beneficial to the environment at the same time.

Bioengineering methods offer the prospect of a cost-effective alternative to conventional engineering methods and are attractive from an environmental standpoint. Successful performance of bioengineering methods requires that the vegetation survive and thrive after installation and provide adequate protection against likely failure modes. Since plant roots do not reach great depths, bioengineering is primarily useful for the mitigation of surface erosion and shallow failures. While the design principles are well known, experience with bioengineering techniques in Ohio is limited and documentation of performance is inadequate. Thus, although a wide variety of vegetation and bioengineering techniques exist, there is little experience within ODOT to guide vegetation selection or provide an optimal design for a given situation.

In order to investigate the potential use of bioengineering methods for stabilization of shallow landslides near Ohio highways, a series of carefully designed, constructed and documented case histories were conducted for ODOT. Particularly important was the investigation of conditions necessary for vegetation installation and survival in the Ohio climate and the demonstration of its contribution to the mitigation of shallow slope failures.

Objectives

The primary objective of the proposed research was to evaluate the applicability of bioengineering methods, including the installation of live willow poles, for the prevention and stabilization of shallow landslides in Ohio. Application to one cut slope and two embankment slopes was investigated. More specific objectives were: 1) to identify important factors that control success or failure of bioengineering methods, 2) to develop installation techniques and designs for successful application of bioengineering methods, and 3) to provide thorough documentation to guide future work in bioengineering for ODOT.

Description

Bioengineering installations were conducted and monitored at three demonstration sites located in Muskingum, Logan and Union Counties. The Muskingum and Union County sites are embankment (fill) slopes, whereas the Logan County site is a cut slope. Shallow slope sliding was a recurring problem at all three sites and willow poles

were installed in an effort to arrest these instabilities. Deep-seated slope movements were also occurring at the Logan County site and a toe berm was constructed to mitigate this problem.

Each demonstration site was heavily instrumented to obtain performance data related to the success of the various stabilization methods. This instrumentation consisted of piezometers, tensiometers and gypsum blocks to measure soil moisture and groundwater conditions; shallow and deep inclinometers and surface surveys to monitor soil and pole movements; and periodic surveys of vegetation to document survivability. Other than site location and specific slope conditions, primary variables for the study were vegetation species and pole installation method. Laboratory soil testing was conducted for each site to obtain input parameters (e.g., shear strength) for stability analysis. Cost data was also obtained for the three bioengineering installations as well for adjacent conventional slope stabilization at the Union County site.

Conclusions & Recommendations

The following conclusions are based on the research conducted in this investigation:

- Bioengineering methods can be effective for the stabilization of shallow slides (less than 3 – 4 ft. deep) if vegetation can be consistently established and maintained for long periods.
- Harvesting and installation of poles should be completed during the dormant season (November 1 to April 15), and preferably during the early spring (March 1 to April 15), and storage after harvesting, even under refrigerated conditions, should be avoided.
- Local climate conditions, and in particular sunlight, temperature and precipitation, have a large impact on the survivability of live poles.
- Pole survival is sensitive to the particular species chosen and soil moisture conditions during the initial growing season.
- The use of soil moisture instrumentation (e.g., tensiometers, piezometers) can be effective for the prediction of vegetation survivability.
- Side-by-side panel comparisons indicated that pole survival is not sensitive to installation method and, therefore, the minimal (least cost) method can be use for routine installation.
- Competitive vegetation growth from weeds and other native plants was problematic at some demonstration sites and can impact pole survivability.
- The results of stability analyses conducted with and without bioengineering stabilization were consistent with field observations of stable and failed slopes.
- The cost of bioengineering stabilization is expected to be approximately 25% less than for conventional construction methods.
- The bioengineering designs were only partially successful in this study due to poor vegetation survivability at some of the demonstration sites.

Implementation Potential

The investigators have concluded that, although important questions have been answered regarding the use of biostabilization in Ohio, the current research is not yet ready for implementation. Additional research will be needed to more clearly establish the potential and limitations of biostabilization as a practical remediation method. If successful, such work may lead to the ultimate goal of producing a geotechnical design bulletin for use of bioengineering for land stabilization.

The general framework for additional research should be:

- Establish which biostabilization methods are most appropriate for a given field site,
- Determine general design guidelines for each method,
- Develop procedures to ensure vegetation survivability, and
- Develop a geotechnical bulletin that provides design guidelines and expected levels of performance for each biostabilization method.