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Evaluation of stability threshold analysis as a cursory method of screening potential streambank stabilization techniques

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Abstract

A water quality issue that is of particular concern in human-modified streams is sediment pollution. In-stream areas of sediment production have been targeted and managed using stream channelization and, more recently, biotechnical streambank stabilization. The objective of this study was to evaluate the use of stability threshold analysis as a cursory method to develop a range of potential streambank stabilization techniques for eroding stream reaches. Stability threshold analysis compares permissible velocity and shear stress thresholds to velocity and shear stress values in stream reaches where stabilization is required. Geomorphological data were collected in four reaches of Cazenovia Creek, NY, where bank erosion has been occurring. Lowflow and bankfull flow velocity and shear stress values for each reach were compared with permissible thresholds for several biotechnical bank stabilization methods. Results indicate that stability threshold analysis provides a simple first step towards determining the appropriate type of bank stabilization to use in eroding reaches and that velocity and shear stress values for this study's sites fall within permissible thresholds for biotechnical streambank stabilization methods.

Keywords: Streambank erosion; Stability threshold analysis; Biotechnical streambank stabilization; Sediment pollution; Watershed management

Introduction

Human modification of watersheds has produced profound changes in streams throughout the US. A growing emphasis on environmental quality has generated concern about the effects of humans on stream ecosystems. One water quality issue that is of particular concern in human-impacted streams is sediment pollution, as sediment is the largest pollutant in our waters by volume and mass. Sources of sediment in a stream may include bed and bank erosion, overland erosion, and discharges from anthropogenic activities (e.g., industrial and municipal discharges and combined sewer overflows). In-stream areas of sediment production have been targeted and managed using stream channelization (i.e., hard engineering) and, more recently, biotechnical streambank stabilization (i.e., soft engineering). Biotechnical bank stabilization uses vegetation to stabilize eroding streambanks instead of large amounts of rock or concrete. The use of

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vegetation to stabilize banks has increasingly become an attractive watershed management solution because natural vegetation is more aesthetically pleasing to local landowners and community members than concrete or rock riprap and it can enhance aquatic habitat in the stream (Li & Eddleman, 2002).

Biotechnical streambank stabilization is a relatively new soft engineering practice that addresses some of the shortcomings of traditional hard stream channelization, such as decreased spatial variability of channel morphology (Brookes, 1988; Dietrich, 1987; Frothingham & Rhoads, 2003; Rhoads & Urban, 1997; Rhoads & Welford, 1991) and the adverse impacts of channelization on aquatic communities (Brookes, 1988; Frothingham, Rhoads, & Herricks, 2001; Gelwick, 1990; Portt, Balon, & Noakes, 1986; Swales, 1988, 1982). Biotechnical streambank stabilization combines vegetation, for example, willow posts and root wads and rock (e.g., riprap) to stabilize unstable banks (Table 1) (Federal Interagency Stream Restoration Working Group (FISRWG), 1998; Fischenich, 2000; Li & Eddleman, 2002; Shields, Cooper, & Knight, 1995; Simon & Steinemann, 2000; Sotir & Nunnally, 1995). In biotechnical projects, vegetation is used to stabilize banks in two primary ways: (1) by reducing water velocity through vegetation near streambanks and (2) roots of the vegetation help support banks and reduce scour. Projects utilizing biotechnical bank stabilization techniques often use natural channel design, which considers the function and stability of streams and their floodplains (Akridge, Eigel, & Athanasakes, 1999; Fischenich, 2000). Natural channel design may include maintaining stream planform pattern, which is an improvement over traditional channelization because spatial variability of channel morphology and, therefore, habitat diversity is preserved. Vegetation also provides shading, cover, and organic material, all of which are beneficial to the biotic functioning of a stream. In addition, streamside vegetation provides habitat for birds and some land animals, as well as insects (Allen & Fischenich, 2000a; Sotir, 1998a). A downfall of biotechnical streambank stabilization is the lack of quantitative post-construction evaluation of the success or failure of projects. Some studies have monitored biotechnical projects after one growing season (Akridge et al., 1999; Shields et al., 1995; Simon & Steinemann, 2000) and success or failure has been noted qualitatively. However, for the most part, quantitative, long-term post-construction evaluation has not widely taken place (with the notable exception of quantitative measures provided by Shields et al., 1995).

The objective of this study was to evaluate the use of stability threshold analysis (Fischenich, 2001) as a cursory method to develop a range of potential streambank stabilization techniques for eroding stream reaches. In particular, the potential to use biotechnical streambank stabilization was investigated. Stability threshold analysis compares permissible velocity and shear stress thresholds to velocity and shear stress values in reaches where stabilization is required. Given that this type of data can be readily obtained, stability threshold analysis ostensibly provides an easy, relatively quick way of determining if biotechnical techniques can be used to stabilize a streambank to reduce sediment input to a stream. The results obtained from stability threshold analysis can be used to inform watershed management decisions. They can, for example, provide justification for further study in the targeted reaches to quantify factors such as dominant erosion processes and soil moisture conditions (FISRWG, 1998; Shields, Copeland, Klingeman, Doyle, & Simon, 2003; Thorne, 1982) and warrant performing the more data intensive and time consuming tractive stress analysis (Goon, 1978; Snover, 1981) that may be needed to develop design specifications. Using stability threshold analysis as a cursory step augmented with a more detailed analysis should increase the likelihood of a successful bank stabilization outcome.

Table 1
Explanation of various types of biotechnical bank stabilization methods

Boundary type	Description
Wattles	Straw (rice or wheat) rolled in natural geotextile fibers, placed in trenches and staked down; provides medium for seeds to sprout and develop root system
Coir roll	Coconut fiber rolls bound together to form cylindrical structures; wetland plants (rooted sprigs, cuttings) typically incorporated into coir roll where roots become interlocked in fibers
Live fascine	Long bundles of live cuttings tied together in linear cylindrical bundles
Live brush mattress	Combination of branch cuttings placed on the bank face, live stakes, and live fascines
Brush layering	Live cuttings installed into streambanks between layers of soil
Live willow stakes	Planting live, rootable willows directly into the soil
Rolled erosion control products (RECPs)	Blankets or mats of natural fibers and long-lasting nets that are rolled over the bank and anchored with staples/stakes