JOINT TRANSPORTATION RESEARCH PROGRAM

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Approaches to the Design of Biotechnical Streambank Stabilization

Volume III—Design Guidelines

Introduction

The Indiana Department of Transportation (INDOT) seeks to diversify the range of standard approaches to streambank protection to include more environmentally sensitive biotechnical techniques emphasizing the use of vegetative elements. In this report, a conceptual framework for the design of biotechnical streambank revetment is proposed based on a literature review and a field assessment of Indiana projects. It is intended to be simple in practice, flexible in being widely applicable, and familiar in retaining certain aspects of current practice while being patterned after other aspects. Consistent with the current INDOT standard designs, the proposed design guidelines are limited to revetment-only solutions, as they are intended as alternatives to the current designs. A specific streambank stability problem may also require other types of solutions, such as in-stream structures, which were considered beyond the scope of this study.

Findings

The proposed framework distinguishes between a toe zone, where traditional hard-armoring techniques such as those already included in the INDOT standard designs are more appropriate, and an upper bank zone where vegetation-based techniques would typically be applied. The boundary elevation, z_v, between the toe zone and the upper bank zone is proposed in general to be the highest of

a. the ordinary high water mark (or equivalently the bankfull stage),
b. the stage corresponding to a 2-year discharge (Q_2),
c. the elevation corresponding to one third (from the bank toe) of the local depth at the bank toe under design discharge conditions.

In specific techniques, this boundary may be higher but will not be lower. This boundary is a reference level and is not necessarily where vegetative elements begin and hard-armor elements end. It is recommended that the hard-armor region extend a short distance above this reference level to allow for post-installation self-adjustment, e.g., settlement, of the hard armor.

Default techniques are identified to simplify the choice of measures for "routine" problems, but more case-specific techniques may also be selected. Primary techniques that offer immediate protection on their own are also distinguished from supplementary techniques that are used only in combination with primary techniques. Default techniques must be primary. For the toe zone, the recommended default is rock riprap as its numerous advantages have made it the current effective default (for the entire streambank). For the upper bank zone, for bank slopes up to 2H:1V, regrading and revegetation with herbaceous species together with the use of rolled erosion control products (RECPs) is proposed as the default. The restriction to streambanks with 2H:1V or flatter is consistent with a similar restriction on rock riprap.

Similar to the different classes of riprap to be used for different flow velocity conditions, two classes of RECPs were defined for use depending on different flow velocity conditions and whether the protected bank is on the outside of a bend or in a relatively straight reach. A class 1 RECP is a 100% biodegradable erosion control blanket (ECB) with a typical functional longevity of 24 months or more and a minimum permissible unvegetated shear stress of 2 lb/ft^2. For more severe conditions, where a class 1 RECP is inadequate to resist the erosional stresses, a class 2 RECP, which is a permanent turf reinforcement mat (TRM), with a minimum permissible design (fully vegetated) shear stress of 8 lb/ft^2, is recommended. Maximum permissible cross-sectionally averaged velocities for the two standard

RECP classes were obtained from a design equation for riprap developed by the U.S. Army Corps of Engineers, based on specified shear stresses and relatively conservative choice of parameter values, for bend flows and for straight-reach flows.

Where default options cannot satisfy design constraints, such as a desire for steeper streambank profile, other primary techniques may be applied. For the toe zone, other hard-armor techniques as described in the INDOT 2013 Hydraulics Design Manual may be applied. For the upper bank zone, the only other non-hard-armor primary technique proposed as a standard design involves the use of vegetated mechanically stabilized earth (VMSE). These, also referred to as vegetated reinforced soil slope (VRSS), or vegetated encapsulated soil lifts, or simply soil lifts, consist of soil encapsulated or wrapped in a facing element or fabric such as an RECP, or a combination of RECPs, that also act a reinforcing element. The choice of fabric wrap would be based on the criteria developed for RECPs. In cases where bank stability must be ensured, such as in the immediate vicinity of a valuable structure, the option to use hard-armor techniques, preferably in a vegetated version, such as the combined use of joint planting with rock riprap, or using vegetated gabions, also remains open for the upper bank zone.

Supplementary techniques are defined as those that may provide environmental/ecological benefits, and though they may also enhance bank stability, these positive effects on bank stability are not relied on in the protection design. They are considered optional but are highly recommended. Two supplementary techniques are proposed, each appropriate for the two primary biotechnical techniques: (i) live staking, used with the regrading/revegetation with the RECP primary-technique default option, and (ii) brush layering, used with soil lifts.

RECP class	**Maximum permissible cross-sectionally averaged velocity, v (ft/s)**	
	Bend flow	**Straight-reach flow**
Class 1 (ECTC classes 3B and 4 ECB)	4.5	6
Class 2 (ECTC classes 5B and 5C TRM)	7.5	10

Transitions between hard-armor and vegetation-based revetments, and also between protected and unprotected reaches, should receive due attention as experience with riprap revetment and biotechnical techniques has shown that failure of the revetment can often be traced to these transitions.

Implementation

It is suggested that a task force be formed to oversee the implementation of the proposed INDOT standard. The task force should include INDOT staff and representatives from the broader community of regulatory agencies, designers, consultants, and construction companies. Because the proposed standard relies heavily on the use of rolled erosion control products, INDOT standard specifications will need to be developed at the beginning of the implementation process. It is recommended that such INDOT standard specifications be based on the already available FHWA FP-03 standard specifications for these products.

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