H21C-0833 MODELLING THE INFLUENCE OF RIPARIAN VEGETATION ON RIVER BANK EROSION

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Introduction

It is widely recognised that riparian vegetation plays a role in determining the stability of river banks with respect to mass failure through its influence on a variety of hydrological (e.g., canopy interception and transpiration), hydraulic (e.g., root reinforcement, mass surcharge) and mechanical (e.g., soil cohesion, soil friction) mechanisms (Greenway, 1987; Morgan and Richmond, 1993). However, quantifying the net contribution of these mechanisms to overall bank stability is still difficult. This is because the influence of vegetation is determined by a complex suite of biophysical properties and their interaction with the physiographic (e.g., climate, hydrology, bank material and geomorphology) characteristics of the site being investigated. Recently, detailed biophysical studies have suggested that the hydrological, thermal and biological properties of the vegetation are opposed to the mechanical, effects of woody vegetation provide a key (albeit seasonally) influence on the stability of the river banks. Herefordshire (Greenway and Colton, 2002). Nevertheless, there remains much scope to build on this valuable research to determine the exact role of vegetative processes. This preliminary statement provides the basis for a PhD research project in which the aim is to identify the influence of riparian vegetation on bank failure processes through a number of study sites covering a range of climatic and physiographic conditions. This paper outlines the methodology and presents preliminary results from one of the study sites.

Methodology

The methodological approach involves the application of geotechnical modelling software GeoSlope International Ltd (2001) and coupled numerical models to simulate vegetative surcharge and stability simulations. To account for root reinforcement, soil cohesion is increased using Wu's method (Wu et al., 1979): C' = C' + 1.2 T RAR (1) where C' is the effective cohesion, T is the tensile strength of the roots (determined by in situ testing, see Figure 3) and RAR is the root area ratio (determined by mapping the root network exposed on the bank face, see Figure 4). The influence of vegetative surcharge is accounted for by adding the root weight in abundance with the biomechanics of the vegetation and the geotechnical properties of the root network. The former is estimated using the method of De Vries (1974), which requires stem height, diameter, and the wood mass density, while the latter is estimated in relation to the observed stem spacing. Finally, the effects of canopy interception are accounted for by decreasing rainfall rates in accordance with changing canopy properties through the year.

Results: River Asker (without pore water pressure)

The Frome's banks are heavily vegetated with young Elm, Willow and Hawthorn for which the majority of roots can be found below the surface. The banks are approximately 2.5 m high, relatively steep and stable. Mean annual precipitation is 756 mm.

Figure 5: River Asker site characteristics

Annual precipitation 1176 mm. The Frome is the segment of the river at about 6.5 km from its source at three terraces. All three terraces are tree and shrub covered with species including Hawthorn and Ash.

Figure 6: Parameter values (Figure 5) in the absence of vegetation have been used in this scenario; three water pressures are obtained as a minimum factor of safety of 1.89. The model presented in Figure 8 is therefore simulated using data from Environment Agency flow gauging stations located at each site.

Results: River Asker (with pore water pressure)

The addition of a hypothetical pore water pressure in the simulations, C' is the effective cohesion, T is the tensile strength tensile strength of the roots (determined by in situ testing, see Figure 3) and RAR is the root area ratio (determined by mapping the root network exposed on the bank face, see Figure 4). The influence of vegetative surcharge is accounted for by adding the root weight in abundance with the biomechanics of the vegetation and the geotechnical properties of the root network. The former is estimated using the method of De Vries (1974), which requires stem height, diameter, and the wood mass density, while the latter is estimated in relation to the observed stem spacing. Finally, the effects of canopy interception are accounted for by decreasing rainfall rates in accordance with changing canopy properties through the year.

Conclusions

These preliminary model simulations show that although the mechanical mechanisms of vegetation, root reinforcement and surcharge are stabilising, the presence of positive pore water pressures hinder the stability of a bank to varying degrees, significantly altering the shape and position of the slip surface. The results from these simulations are also used to calibrate the full scale model and provide a basis for further research.

References


Figure 1: Study site locations in England and Wales

The sites cover a range of physiographic and climatic settings allowing for the net effects of vegetation under a variety of conditions.

Figure 2: Iowa bore

and surcharge simulated in Figure 7 are reproduced, but with the addition of a hypothetical pore water pressure ratio (Figure 5) is 2.69. This indicates that the minimum factor of safety of 2.5 suggests pore water pressure reduces bank stability but vegetation still effectively maintains overall stability.