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The influence of biota on surface erosion phenomenon of earth levee

Valeria Pennisi (1), Rosaria Ester Musumeci (1), Stuart James McLelland (2), Laura Maria Stancanelli (1), Antonio Cancelliere (1), and Enrico Foti (1)

(1) Catania, Civil Engineering and Architecture, Italy (pennisivaleria@gmail.com), (2) Hull, Environmental Sciences, UK (s.j.mclelland@hull.ac.uk)

The failure of levees is one of the main causes of catastrophic flooding. Different failure mechanisms are widely studied, however frequently federal, state, and local agencies in the world reported failures in earth structures due to less obvious reasons; such as the impact of biota on river ecosystem.
Burrowing animals, like coypus and crayfish, may compromise the hydraulic performance and structural integrity of earth levees. A wide range of intrusive burrows dug by wildlife with different patterns of burrow diameter, depth and orientation lead to mass removal and subsequent physical deformation as well as enhanced seepage pathways that can accelerate soil piping mechanisms and structural erosion. Thus, evaluation of the vulnerability of earth structures must account for the impact of burrowing biota.
Unfortunately, den systems are extremely complex and therefore difficult to model using conventional techniques. For this reason, experimental research using analogue models may help to understand the relative importance of geometrical, topological and hydraulic parameters of burrowing activities.
The present study investigates the impact of different idealized configurations of animal burrows on the vulnerability of an earth levee. To this aim, experiments on a physically based analogue model of an undisturbed and disturbed levee have been carried out at the University of Hull (UK). The effect of burrow density, den length, position relative to water level and angle relative to the flow direction are investigated.
The earth levee has a trapezoidal section, 5 cm high, and the bank slope is 1:1. Different sediment mixtures have been considered (fine sand, mix of clay and sand, medium sand) to build the structure. Most of the tests presented here refer to the fine sand levees since these are those more affected by the presence of dens.
The animal burrows are modeled as cylindrical cavities created with a glass rod 6 mm in diameter.
The pattern of levee erosion has been quantified using time-lapse GoPro images collected from above the flume, capturing the evolution of riverside slope erosion at 5 second intervals.
During all the experimental activities, the hydraulic parameters are controlled and monitored with fixed gauges and a miniature propeller current meter to set the water depth and flow velocity. A piezometer is also used to evaluate the evolution of seepage through the levee and to monitor pressure changes during the test.
Experimental results show that, compared with an undisturbed levee, different burrow configurations may affect the erosional processes in different ways, for example burrows located above water level tend to increase the rate of erosion compared to those located below water level. Moreover, the orientation of burrows with respect to flow direction plays an important role: greater erosion is observed with burrows oriented at 45° and 135° to the flow direction. In addition, longer dens produced larger eroded volumes; whilst burrow density does not play a significant role in the present tests.