Flood Infrastructure: Localized Scour at Piano Key Weirs

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Historic growth in the US has placed new demands on our water infrastructure, including dams, levees, and control structures in rivers. This growth coupled with observed hydrologic changes, such as more frequent flooding, has resulted in an increased demand for sustainable flood protection. A critical component to our dams, levees, and rivers that handle flood waters are the various spillways and control structures. One innovative group of spillways are nonlinear weirs such as labyrinth and Piano Key weirs (PK weirs). Although these types of spillways are being designed and constructed with greater frequency, flood flows often produce unwanted or excessive scour that could compromise functionality or stability of the hydraulic structure. Local scour undermining a spillway or basin is a complex process depending on structure geometry, flow characteristics and duration, bed shear stresses, turbulence intensity and sediment properties. Earlier studies have primarily focused on jet-driven scour, scour at linear weirs, culverts and bridge piers. Despite the critical role of dams and spillways, design guidelines to predict and mitigate local scour is limited for practitioners (ASCE Task Committee on Scour at Channel-control Structures, personal communication, 2020). Therefore, additional guidance for predicting local scour at spillways would be of value to the dam safety community. In consideration of the growing popularity of PK weirs at various types of dams and in rivers, a large-scale laboratory study has been undertaken at Utah State University. Such study allowed us to investigate the scour mechanism at the foundation of a Piano Key weir and size cutoff walls for terminal structures. The objectives of this study include: Quantifying the maximum scour depths and scour morphology Developing first principles based approaches for scour prediction Providing guidance regarding downstream apron lengths and corresponding cutoff wall depths to protect PK weir foundations This study is funded by the State of Utah, the US Geologic Survey, and is in collaboration with the University of California Davis and the University of Pisa, Italy. This paper presents the preliminary results for maximum scour depths and geometries for a noncohesive gravel for various flow rates and tailwater conditions. Instrumentation for data collection included 3D cameras and ultrasonic sensors to capture scour features and measure dynamic water surface elevations, respectively.