Piano Key Weir Considerations in Northern Climates

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The City of Albany, NY was first settled in 1614 and the first water supply system was built in 1678. As the city's population increased, the water supply system was expanded and now includes a portfolio of six dams constructed between 1850 and 1928. The primary water supply reservoirs are Alcove Reservoir and Basic Creek Reservoir located 16 miles southwest of the City. Schnabel was retained by the City in 2015 to perform engineering assessments for the City's portfolio of dams. Basic Creek Reservoir is a high hazard earthen embankment with a height of approximately 25 feet, approximately 870 feet in length and impounds a maximum of 3920 ac-ft water. Detailed hydrologic and hydraulic analyses were performed to assess the dam's compliance with spillway capacity requirements. A comprehensive geotechnical exploration program, laboratory testing and seismic and slope stability analyses were performed on the embankment and foundation materials. The results of the engineering assessment concluded that the dam had significant deficiencies in spillway capacity, and the foundation were susceptible to significant seismic deformation. Schnabel performed detailed alternatives analyses to identify cost-effective remedial measures to bring the dam into regulatory compliance. Spillway alternatives evaluated included: a labyrinth weir, a new auxiliary spillway, incremental design flood study, raising the embankments, lowering the pool/hazard classification, an Obermeyer pneumatically actuated gate, and a staged piano key (PK) weir constructed on top of the existing concrete spillway. The PK weir was ultimately selected for detailed design due to its functionality and limited long-term maintenance required. The structural design of the PK weir was complicated by the cold weather climate and involved developing a three-dimensional (3-D) finite element model to estimate the various stress distributions in the piano key divider walls and ramps. A unique consideration for the design was predicting stresses caused by outward thermal expansion of ice contained within the inlet keys as thermal ice expansion was found to control over other evaluated load cases for the structural design of the divider walls. This led to a complex reinforcement layout for resisting anticipated stresses. Detailed 3-D computational fluid dynamics modeling was performed to refine the performance of the PK weir. Geotechnical design improvements include installation of deep soil-cement mixed panels within the foundation soils to improve foundation performance during seismic loading conditions. This presentation will highlight the unique challenges of the remedial design including for the northernmost PK weirs subject to significant ice loading.