Presentation

Slipline Considerations

Vic Robbins, engineer, King and Associates Engineering, Kansas Dam Safety Conference, 15 February 2012, Topeka, KS.

When deciding to use sliplining in spillway pipe rehabilitation, first decide whether the site is a good candidate, Vic Robbins said. One reason is its relatively higher cost, about $200 a foot, compared with alternatives. This expense, in part, is because companies typically lay thousands of pipe feet rather than a couple of hundred feet and because of mobilization costs, usually about a third of the total. For example, it's easier to replace conduits in small dams than slipline. However, if a dam has substantial fill, a drop inlet, road on top, or needed water supply reservoir, sliplining might be the optimum rehabilitation.

After determining site suitability, do a preliminary investigation to find whether the existing pipe is suitable to slipline. If leakage isn't obvious, for instance, if water is going out the pipe with none going in, then the pipe is leaking. Plug the downstream pipe end, fill it with water, measure how fast water flows, and if it exceeds Division of Water Resources allowance rates, then the pipe probably should be lined. Next, video inspect the pipe with a remote camera to look for collapsed areas, deflection, and other problems restricting liner insertion. Look, too, for large bends such as the elbow bends found in 1970s era principal spillways that prevent liners from being pulled through. Large holes and voids can be problematic also because they can extend to the embankment outside the pipe.

Once sliplining possibility has been confirmed, conduct a structural design. The primary design standard is ASTM F-1216 and standards by the American Waterworks Association have additional requirements. Assume the host pipe is fully deteriorated because it will be in time and don't assign strength to the host pipe nor grout. The new liner must be able to support all imposed external short- and long-term loads (e.g., soil, groundwater, traffic, and grouting pressure). Design considerations can assign a high strength number to soil because a fully consolidated soil tunnel around existing pipe will carry a lot of the imposed load. Consider using a soil strength modulus of 750 psi, which is about twice the normal, Robbins said. Analyze for wall buckling and also wall crushing, both of which should have a safety factor of 2 or more. Kansas regulations require that a pipe under full load for its full life shouldn't deflect more than 5 percent. Also, look at ring bending stress; as the pipe deflects, it

creates high stresses on the pipe haunches.

Calculate minimum bending radius so the installed pipe is not over stressed by bending. Also account for thermal expansion and contraction. For example, a 30 degree temperature change after a pipe goes in and cools in the earth can change pipe length by 4" and affect joints and seals. Calculate, too, maximum pulling strength to avoid pipe stress.

Before installation, high pressure clean the host pipe, do another video inspection, and administer a Mandrel test for deflection. "We use a continuous pipe with thermal fusion butt welding. There are others that have snap connectors or screw connectors, but butt fusion is best," said Robbins, who also cautioned about liner buoyancy in grout, which requires spacer blocks or skids for centering.

"Keep about a 1" gap between pipe and spacer," Robbins said. "And grout from the downstream to the up end so all voids get filled. Normally, the grout is cement and a lot of water that looks like thin pancake batter. Air content should be 20 percent or greater to reduce viscosity and density. Pump all the way through just to fill void. Be sure to monitor grout pressure constantly so the pipe doesn't collapse."

Using the example of a 26' wide dam with a country road over in the Wet Walnut Watershed District, Robbins said the site was deemed suitable for sliplining because the original pipe had rust but no perforation in one part, good alignment, and didn't have any visible deflection. "When we did the pre-installation video camera, the pipe looked pretty good except there were a number of rocks. The contractor didn't want to bring in a pressure washer at that expense to remove a few rocks. So, they made this basket and put it on a long piece of rebar, drug it through about 10 times, then tried to flush it out with a 3" water pump." Eventually, a crew member crawled through the pipe and cleaned up all the rocks.

After another video inspection, Robbins and the contractor lined up the fused liner pipe with supports and with pulleys and cables pulled it through the original pipe. They brought water to the site and added equal parts Portland cement and fly ash along with aerating and foaming agents. They tested the density several times to get it down to 80 pounds per cubic foot and air up 20 percent air. The concrete truck below the dam dumped grout into a plastic hopper and the grout was pumped in with a 2" gas-powered water transfer pump.

Entering grout at 80 degrees and 40 degree outside expanded the pipe, and then internal vacuuming became an issue. "When the principal spillway system is orifice controlled either at the orifice coming in at the barrel or orifice at top of riser, it can develop a vacuum within the barrel because the pipe primes and actually sucks water through those orifices. In this case since we had a 3.03 safety factor against buckling, there wasn't any problem. The pipe can easily withstand the internal vacuum."