Repair of Choke Canyon Dam Outlet Works
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Abstract
Choke Canyon Dam is a 3.5 mile long earthen dam owned by the U.S. Bureau of Reclamation (Reclamation) and operated by the City of Corpus Christi. The dam is classified as a large, high hazard dam by the Texas Commission on Environmental Quality. The dam forms Choke Canyon reservoir which is a primary water supply for the City of Corpus Christi. The outlet works discharges into a concrete stilling basin. The basin concrete had been damaged to the point that reinforcing steel was exposed. Model studies by Reclamation in the early 1990’s showed this type of basin is prone to abrasion damage caused by downstream channel material being pulled into the basin by bottom currents that flow upstream. As part of the Choke Canyon Dam repairs, model studies were used to confirm abrasion as the cause of damage and to design a deflector to correct the flow conditions. The deflector was installed at Choke Canyon in 2006. This paper presents the findings of the studies and provides information that can be used in repairing similar damage in reservoir outlet works.

Background
Construction of Choke Canyon Dam was completed in 1982. The City of Corpus Christi has operated and maintained the dam since completion. The dam has a gated ogee spillway to pass large flood events. Normal river flows are released through an 8-ft diameter pipe. The outlet works capacity is 2,000 cfs. The minimum flow is 33 cfs to meet instream flow requirements. The pipe discharges into two 10-ft wide stilling basins for energy dissipation. The stilling basins are Reclamation Type II design. Type II stilling basins consist of chute blocks at the upstream end of the basin and a dentated sill near the downstream end. The stilling basin dissipates energy by causing a hydraulic jump within the basin that protects the downstream river channel from the high velocity flow released from the reservoir.

Figure 1: Choke Canyon Dam

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The City of Corpus Christi noticed concrete damage in the outlet works stilling basin in 1994. There had been approximately 2 to 3 inches of concrete loss on the floor and ½ to 1 inch on the side walls. Steel reinforcement was exposed in the chute blocks (Figure 2). The damage was attributed to abrasion by a mixture of sand, gravel, and shells in the basin. The City began an investigation to confirm abrasion as the cause of the damage and to evaluate methods to prevent further damage.

![Concrete damage and exposed reinforcing steel.](image)

**Figure 2: Concrete damage and exposed reinforcing steel.**

**Model Study**

1:10 scale models of the Choke Canyon Dam stilling basin were constructed at Utah State University’s Utah Water Research Laboratory (Figure 3) and by Reclamation’s Hydraulic Investigations and Laboratory Services Group in Denver, Colorado. The models were constructed of clear acrylic to allow observation of the flow inside the basin. The models allowed for studying many alternatives to evaluate their performance. Modeling is a great tool to investigate options without building them in the real structure and releasing the lake water downstream.
The first phase of the model study was to confirm that flow conditions existed that could draw material into the basin leading to the noted damage. The tests showed that the direction of flow near the channel bottom was upstream except for very high flowrates. The direction of flow at the surface was in the downstream direction (Figure 4). The upstream velocities were sufficient to sweep abrasive material from the downstream channel into the stilling basin. Once material was in the basin, the turbulent flow continually moved the material around. The material remained in the basin and could not be swept out until the flowrate approached maximum discharge capacity.

The second phase of the model study was to investigate methods to prevent the upstream flows that bring material into the basin. A flow deflector developed through research conducted by Reclamation’s Hydraulic Investigations and Laboratory Services group was installed above the endsill to intercept the downstream flow at the surface and redirect it to the endsill (Figure 5). A patent was awarded to Reclamation for the deflector design in March 2007. The model showed
that the deflector was successful at maintaining downstream flow at the channel bottom. Figure 6 illustrates the flow patterns in the basin with the deflector installed.

![Figure 5: Deflector installed in model at Utah Water Research Laboratory.](image)

**Figure 6: Flow patterns in basin with deflector installed.**

**Field Study**

Once the model results indicated that the deflector could solve the problem, the City of Corpus Christi proceeded with final design of the deflector and concrete repair. Velocity measurements were taken at Choke Canyon Dam over a range of discharges to confirm the model results. The Bureau of Reclamation designed the deflector and determined the preferred size and positioning based on results of the field measurements and additional model studies they have performed. Freese and Nichols developed the overall repair design and assisted the owner in procuring bids for the project. The concrete repair included removal of the damaged concrete to 1 ½ inches below the reinforcing steel. New silica fume concrete was placed to the original dimensions.
Construction

The City of Corpus Christi contracted with Holloman Corporation in July 2006 to repair the concrete damage and install the deflectors in the stilling basins. The total bid amount was $309,000. This included the deflectors, concrete repair in the outlet works and the spillway, and a buoy line around the intake. The bid price for both deflectors was $57,000. The deflector was installed in December 2006 (Figure 7). The flow velocities were again measured following installation. The results confirmed that the flow directions were consistently downstream correcting the problem that led to the scour damage.

Conclusion

The deflector installed in the Choke Canyon Dam outlet works stilling basin prevents the bottom currents from flowing upstream. The deflector design is an example of successful use of physical model studies as an aid in design. The deflector should maintain the basin free of abrasive material, which will extend the life of the stilling basin. A deflector should be considered for similar stilling basins with abrasion damage. This project is a great example of the City, the Federal Government, and a private consultant partnering together to solve dam safety problems.