Concrete Penstock Liner Damage Repaired with Crack Injection

In a large concrete penstock liner in Central California, severe lateral and radial cracks as well as leaking control joints were repaired successfully with a high strength epoxy injection adhesive. An earthquake started the damage in 1964, less than one year after the concrete liner had been constructed.

The liner sheathes a 7.5-ft. diameter steel penstock which feeds a low voltage, low capacity generator. The penstock and liner lie in the center of an earth-filled dam which is 1600 ft. long across a canyon, 220 ft. high and 390 ft. thick at the base.

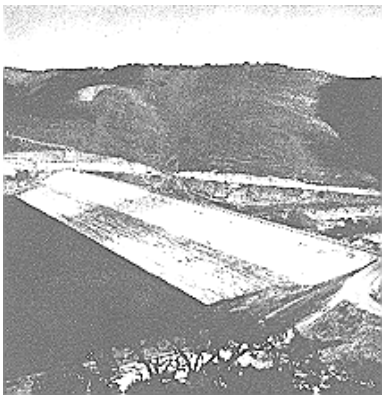
The concrete liner is 780 ft. long and runs at a 90° angle to the dam structure. It has 3-ft. thick walls and roof and a 4-ft. thick floor. Control joints are spaced on 60-ft. centers, and each joint has a pvc waterstop embedded 15 in. in from the interior face of the concrete. A gutter was installed in the liner to carry off small amounts of free water.

Immediately after the earthquake, random lateral cracks appeared in the concrete roof parallel to the tunnel. The cracks at that time ranged from extremely fine hairlines to some 0.020-in. wide.

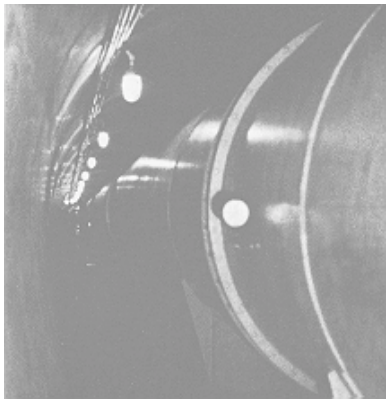
By late 1967, cracking of the concrete had become progressively worse. Radial cracks in the concrete varied from the hardly noticeable to quite a few about 0.120-in. wide. Large quantities of water poured through radial cracks, causing much concern because of the increasing danger of corrosion to the steel penstock and automatic water control equipment. One crack was flowing about 4 gals. of water per minute.

Another hazard was the increasing build-up of hydrogen sulphide gas formed largely by natural sulphur deposits and raw asphaltic materials.The gas, which showed up as a frothy substance in the crack areas, was corroding the reinforcing steel in the concrete liner.

Repairing the concrete. Note discoloration marks left by the water flowing into the liner.



One of the larger structures of its type, the earth-filled dam is 1600 ft. long across a canyon, 220 ft. high and 390 ft. thick at the base.



An overall view of the 71/2 ft. diameter steel penstock which extends the full length of the 780 ft. long, 3 ft. thick concrete liner.

In the control joints, the leakage problem seemed to be the honeycomb areas of rock pockets that were permitting the flowing water to bypass the plastic waterstops and enter the joints to the inside of the concrete liner.

Prior to the crack injection of epoxy adhesives, several attempts had been made to stop the flow of water. The surfaces of the cracks were v-routed and packed with a flexible compound designed to take the anticipated movement within the crack plane. Due to the continually wet condition the material (lid not adhere, and the repairs were totally ineffective.

The cracks and control joints were filled in Spring 1968 with a low viscosity structural injection resin. The repairs, which restored the structural integrity of the concrete liner, were handled in three phases:

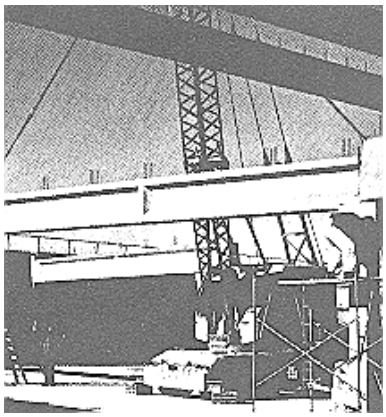
1. Radial cracking. There were 13 random radial cracks in the 12 ft. diameter concrete liner, each about 37 lineal feet long. A fast-setting temporary seal was applied over the cracks.

In some areas, it was necessary to relieve the water pressure by installing relief stems at an angle which allowed the water to escape through the orifice.

The epoxy adhesive was injected under pressure through openings in the seal. The adhesive is unusual in that it will displace water from a surface as it is introduced, thus ensuring a structural bond. The largest of the radial cracks required 14 gals. of adhesive; the finest (about 0.004 in. wide) took ¾-gal.

2. Lateral cracking. There were about 200 lin. ft. of random lateral cracking in the concrete roof, requiring penetration of the epoxy adhesive to the full depth of the crack. Since none of these cracks was flowing water, no orifices were needed to relieve the water pressure. All of the lateral cracks were repaired in 1-1/2 days, and required about 4-1/2 gals. of epoxy adhesive.

3. Control joints. The leakage of water through these joints was halted by pressure injecting the epoxy adhesive down through the concrete to the pvc waterstops. The amount of material required for repair was therefore much less than that used to repair the lateral and radial cracks.



This large beam in a major Western prestressed concrete yard was successfully repaired with crack injection saving the contractor many hundreds of dollars.

Structural Epoxy Repairs Cracked Prestressed Beams

Cracked prestressed and post-tensioned beams and girders designed to sustain high structural loads can be restored to full design strength by the crack injection process--in a short time and at relatively negligible cost. In addition, the adhesive seals out moisture and protects the highly tensioned steel stressing cables from corrosion.

In one large precasting yard, several double-T beams had developed cracks which were about 0.010 in. wide running at a 90' angle across the prestressing cables. Low viscosity epoxy injected at high pressure into the full depth of the cracks filled the voids and bonded the concrete permanently.

The unique crack repair process is also suitable for precast concrete pipe, sculptured concrete members, exposed aggregate panels and tilt-up slabs.