Invert Replacement of Corrugated Metal Structural Plate Pipe

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ABSTRACT

Most highway departments will eventually be faced with the problem of how to extend the useful service life of deteriorated drainage structures where the cost of actual replacement would be prohibitive. When faced with such a situation, the Alabama Highway Department chose to replace worn inverts of a large diameter corrugated metal structural plate pipe with steel armor plating. The installation of these armor-plated inverts has significantly increased the useful service life of the existing pipe for a fraction of what the actual replacement cost would have been.

Most highway departments will eventually face the problem of extending the useful life of deteriorated drainage structures in locations where actual replacement cost is prohibitive. When faced with the problem of repairing worn inverts of large diameter corrugated metal (CM) structural plate pipe, the Alabama Highway Department installed steel armor plating in the existing pipe, thus extending the useful service life.

A triple line of 84-in.-diameter CM structural plate pipe was experiencing severe invert deterioration. This deterioration was caused by an abrasive bedload of sandstone flowing through the pipe at high velocities. There was no indication that acidic flow conditions contributed to the deterioration of the inverts, because low flow pH was measured in the range of 7.0 to 8.0.

The triple line of pipe is located in an area known as Hurricane Hollow on US-31 at Hurricane Creek in Cullman County, Alabama. The structural plate pipes are each 517 ft long and are located under a roadway fill of approximately 135 ft. In periods of heavy rainfall the pipes operate under headwater depths of 40 ft or greater (see Figure 1).

With the exception of the deteriorated inverts, each pipe was in good structural condition, and the fill over the pipes had experienced little settlement since original construction. Replacing these pipes would have been cost prohibitive; therefore a method of repairing the inverts had to be devised before deterioration reached an advanced stage that would threaten the structural integrity of the pipes and roadway fill.

When originally constructed in 1952 the CM structural plate pipes were bituminous coated both inside and out for corrosion resistance. But because of the abrasive bedload, the bituminous coating was soon eroded from the invert and the need for an erosion-resistant invert was evident. Alabama Highway Department maintenance forces attempted to solve the abrasion problem by placing a liner of bituminous wearing layer, approximately 4 in. thick, in the pipe inverts. The bituminous liner, however, could not withstand the abrasive bedload and deterioration occurred rapidly, and eventually the metal pipe inverts became severely eroded.

In 1971 the Alabama Highway Department proposed corrective measures, which included welding 0.1875-in. pencil bars to the inverts, tying welded wire fabric to the rods, and then placing a gunite liner in the inverts. This proposal was abandoned because it was believed that the steel armor-plated invert was a more permanent corrective measure.

In 1973 the Alabama Highway Department let a contract to repair the deteriorated inverts with steel armor plating. The contract specified the installation of a shaped, 0.1875-in. steel armor plate in the existing pipes. The invert armor plate and the existing pipes were to be provided with concrete anchor studs (KSM or Nelson Studs) with a concrete mortar bed to bond the pipe and armor plate together (see Figure 2). The length of armor plate sections and handling procedures were left to the contrac-

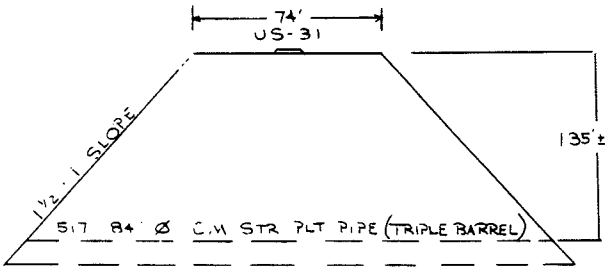

FIGURE 1 Cross section of roadway fill.

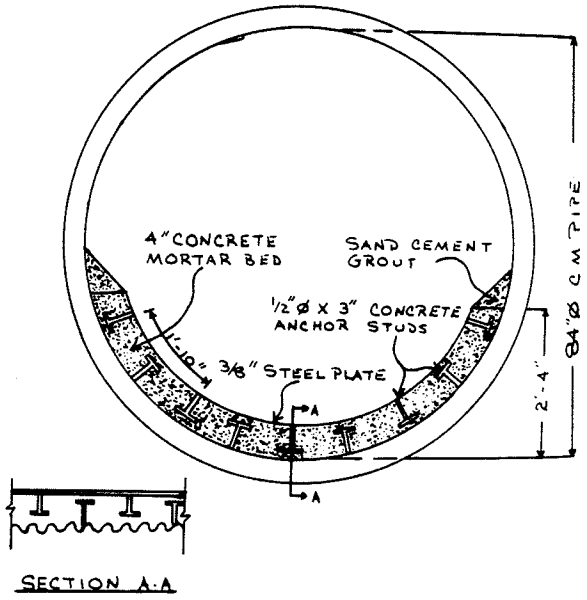

FIGURE 2 Armor plate—typical section.

tor's discretion. In addition to the invert repair, the contract also provided for construction of a retaining wall at the outlet end, slope paved aprons at both the inlet and the outlet, and special paved ditches down the roadway embankment slopes.

Initial construction consisted of attaching an overhead monorail system to the crown of the pipes for transporting the steel armor plates. The plates were 0.375 x 90.75 x 98 in., each weighed 945 lb, were preshaped, and were fitted with the required number of studs. The monorail system provided an efficient means of transporting the plates within the 84-in.-diameter pipes (see Figure 3).

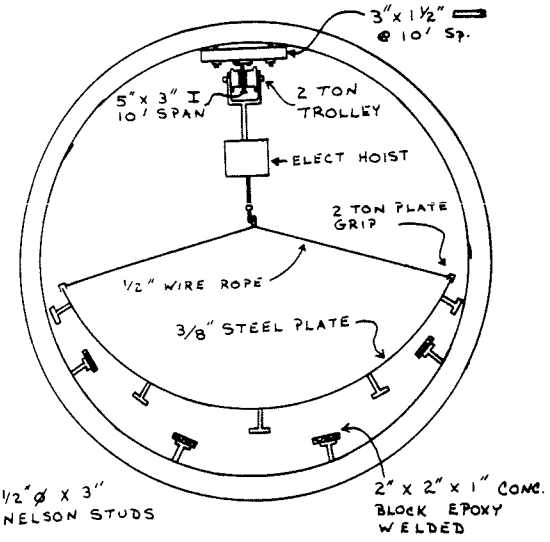

FIGURE 3 Method of installation.

Before the armor plates could be installed in a pipe, a diversion dam was built to block water from one pipe and divert it through the other two pipes. Groundwater entering through cracks in the pipe walls was halted with a quick-setting cement seal. Once all water was eliminated, the concrete anchor studs were welded to the existing pipe invert, a concrete mortar bed was placed, and the plates were lowered vertically into the mortar bed. This procedure was followed initially, but it was found to be unsatisfactory when the concrete mortar bed was vibrated to remove voids under the plates. Vibrations of the mortar bed caused movement of the plates, and difficulty in alignment resulted. Therefore, the sequence was revised as follows: set three plates; tack weld, brace, and place concrete; and vibrate to remove voids. After allowing the concrete to cure for 7 days, the braces were removed and the plates were welded together. Varying alignment and profile of the existing pipes caused gaps between adjoining armor plates. Strips of steel armor plate were welded in place to close these gaps. An epoxy was then placed on the unfinished concrete edges, and a sand-cement grout was applied to obtain a uniform finish. The contractor was required to regalvanize damaged areas after removing the monorail system.

The last section of steel armor-plated invert was installed in June 1974, and the project was completed in January 1975. The installation of the steel armor plated inverts was bid at $103 per linear foot for a total of $160,041.40; the total project cost was $325,034.

After 9 years of service the steel armor-plated inverts are functioning well, with no adverse wear. The CM structural plate pipes have now been in service for approximately 31 years and are functioning well, with the exception of leakage at some of the joints. The installation of the steel armor-plated inverts has extended the useful service life of the triple line of 84-in.-diameter pipe for a fraction of what actual replacement costs would have been.

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