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POTENTIAL PROBLEMS ON I-77 CONCRETE CULVERT

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Virginia Highway & Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the Virginia
Department of Highways & Transportation and the University of Virginia)

Charlottesville, Virginia
May 1976
VHTRC 76-R55

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CULVERT INSTALLATION

Interstate 77 provides a north-south route through the southwestern part of Virginia, and links the West Virginia Turnpike and the piedmont region of North Carolina through the Blue Ridge Mountains in Carroll County. In one of the high, 256 feet (78 meters), fills through the mountains, two pipe culverts, one a temporary structure of corrugated steel construction and the other a permanent reinforced concrete drain, have been installed to carry a native trout stream under the roadway.

The temporary culvert was designed to provide drainage until the permanent culvert was installed. The latter pipe was constructed of C-5 reinforced concrete meeting the requirements of Class A5 concrete (VDHT Specs), and has an inside diameter of 8 feet (2.44 meters) and a wall thickness of 9 inches (0.2 meters). It was installed in a trench excavated after the fill was approximately 10 feet (3.05 meters) above the elevation of the culvert, and rests on a crushed stone bedding placed in the bottom of the trench at the grade of the culvert. After the sections of the culvert were put in position, layers of backfill were placed and compacted around them. Bales of straw were then stacked over the entire length of the backfill and the culvert (approximately 800 feet (244 meters)). The straw was placed the width of the pipe (9.5 feet (2.9 meters)) and to a height of 19 feet (5.8 meters) as shown in Figure 1. After placement of the straw the fill was built up to the plan elevation. The concrete pipe is 100 feet (30.5 meters) higher than the temporary steel drain and is overlain by 150 feet (46 meters) of fill.

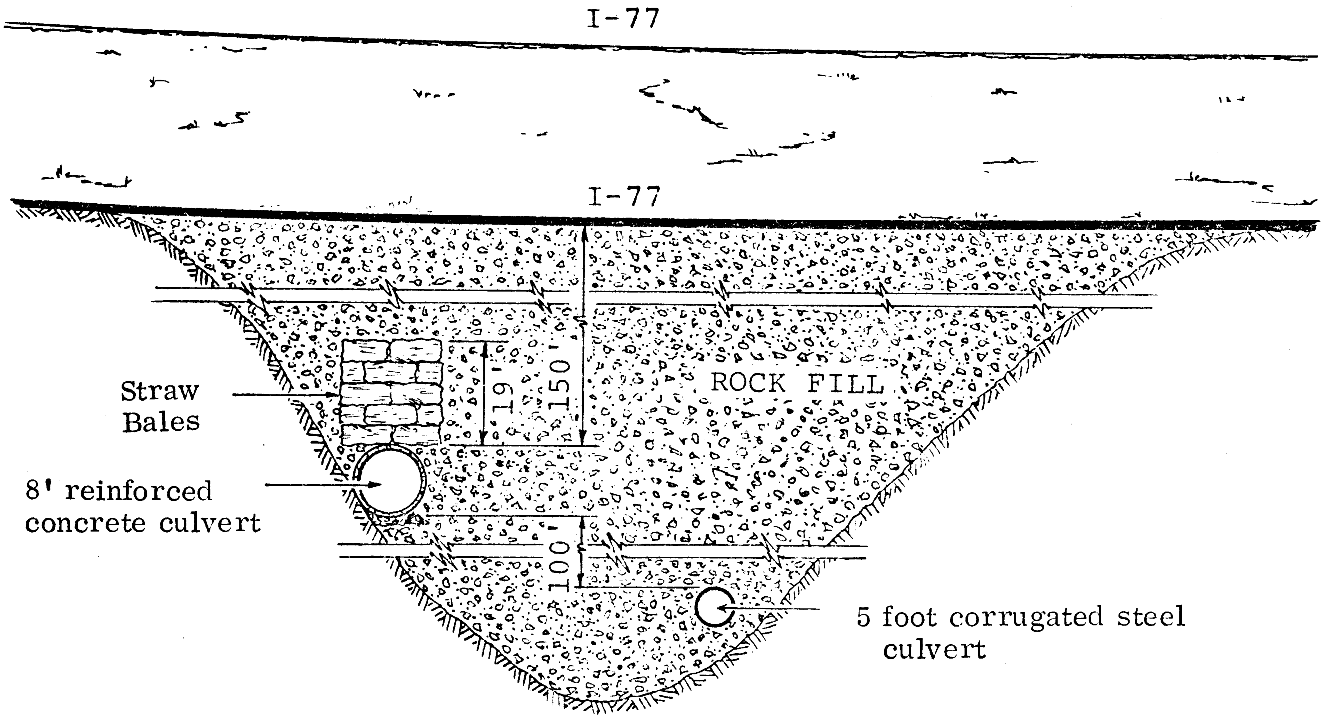

Figure 1. Sketch of culvert installation.

CHEMICAL ATTACK

During the course of investigation of another research project on this culvert, it was noticed that the straw above the culvert was decaying. A check of the literature showed that the decomposition of organic materials, such as straw, produces organic acids that attack concrete. In most cases the resulting damage is not severe enough to cause structural problems, but it was thought prudent to determine if any chemical attack was occurring on this culvert.

Because it was impossible to examine the exterior of the culvert, the water seeping in from the top was sampled and analyzed for the presence of organic acids. The locations of the sampling points are shown in Figure 2.

To determine any differences in the samples that might be attributable to chemical attack on the concrete, it was necessary to make two assumptions: (1) The water influx into the straw was the same over the length of pipe studied; and (2) because of the slope of the culvert, there was a general movement of water along the top of the pipe from sample site A to sample site B. Because of these assumptions the conclusions drawn from the data provide evidence for only the possibility of chemical attack on the concrete. The results are shown in Table 1.

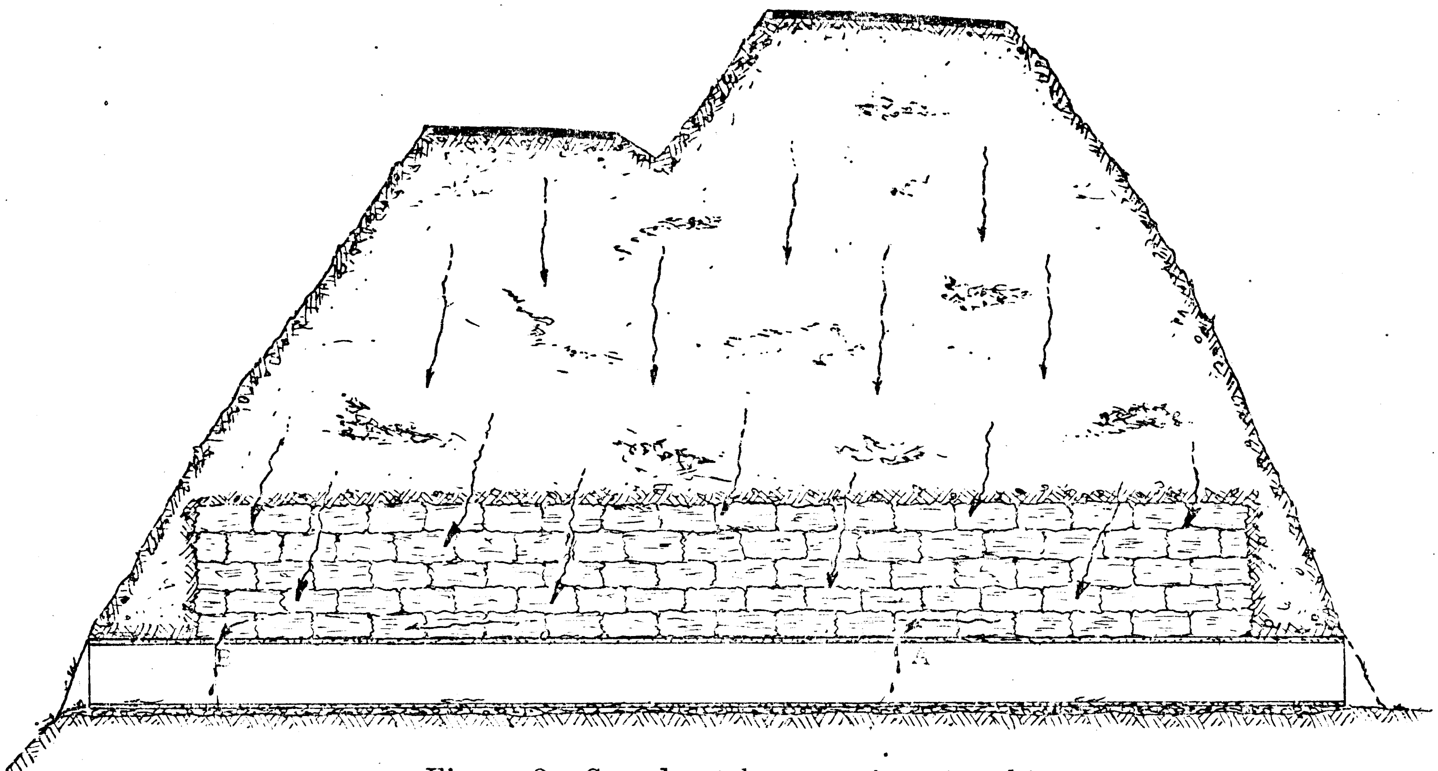

Figure 2. Samples taken at points A and B.

Table 1

ANALYSES OF WATER FROM TOP OF CULVERT

Test	Site A	Site B
pH	5.0	5.6
dissolved solids	640 ppm	720 ppm
SO_4	<10 ppm	<10 ppm
total alkalinity to pH 4.5 (expressed as ppm $CaCO_3$)	140 ppm	190 ppm

The results indicate the possibility that chemical attack of the concrete is occurring. The higher values for pH, alkalinity, and dissolved solids at site B all indicate that some of the concrete is being dissolved as the water flows from site A to site B. The low SO_4 values indicate that no sulfate attack is occurring.

To further investigate the conclusion that portions of the pipe are dissolving because of the chemical composition of the water, the following experiment was set up. Two 20-gram samples of pulverized concrete were placed in separate containers. To one of these containers 400 ml of water from site A was added; to the other 400 ml of distilled, deionized water. These samples were allowed to soak for 56 hours, and then the solid residue was filtered, dried, and weighed. The water sample from site A dissolved 0.5% more concrete than did the distilled, deionized water. (All materials are soluble to varying extents in water, and the amount of material dissolved in distilled, deionized water usually is greater than that dissolved in natural waters because of the greater amount of material that must dissolve to reach ionic equilibrium). The greater amount of concrete dissolved in the water from site A indicates that the chemical nature of the water causes it to be corrosive to concrete.

CRACKS AND FISSURES

The chemical attack on the concrete associated with the decay of the straw is a slow process and a secondary problem when compared to the problem caused by the small cracks and fissures which were noticed during the collection of the water samples. The water now penetrating the cracks and reaching the reinforcing steel in the culvert is causing corrosion of the reinforcement and spalling of the concrete, which is a major structural problem. The corrosion of the reinforcing steel is evidenced by the discoloration along many of the cracks as illustrated in Figures 3 and 4.

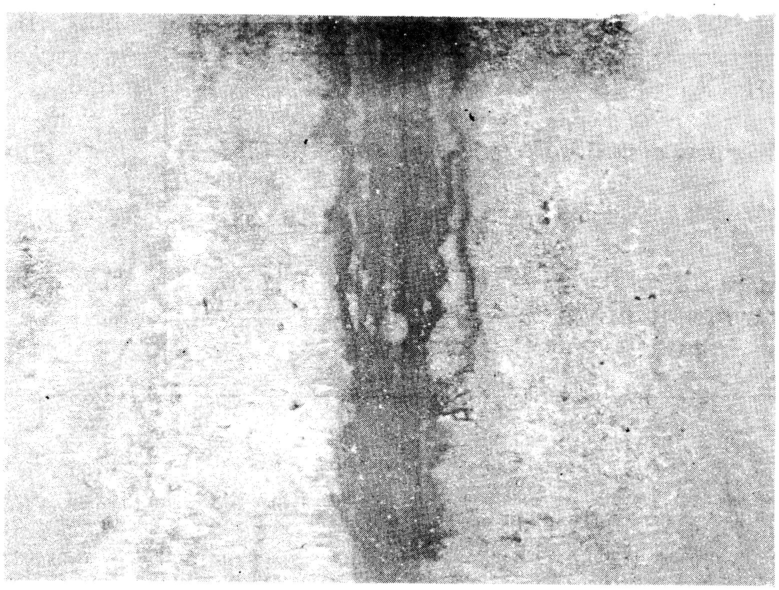

Figure 3. Discoloration from corrosion of reinforcing steel.

Figure 4. Large number of small cracks showing discoloration.

The structural cracks and spalled areas are quite large in the culvert sections under the deep part of the fill (Figure 5). The large cracks with exposed reinforcement occur at 10 and 2 o'clock on the inside of the culvert. The cracks are the largest in these areas because the culvert was designed with the straw backfill to reduce the earth pressure on top of the culvert and distribute the pressure to its sides. With the large inward pressure on the culvert's sides and only minimal pressure on the top, it is quite possible that tensile cracks are present on the outside of the top of the culvert. With these cracks being probable and the corrosive water being readily available, it is quite certain that the reinforcement is being corroded and the structural strength of the culvert is being reduced.

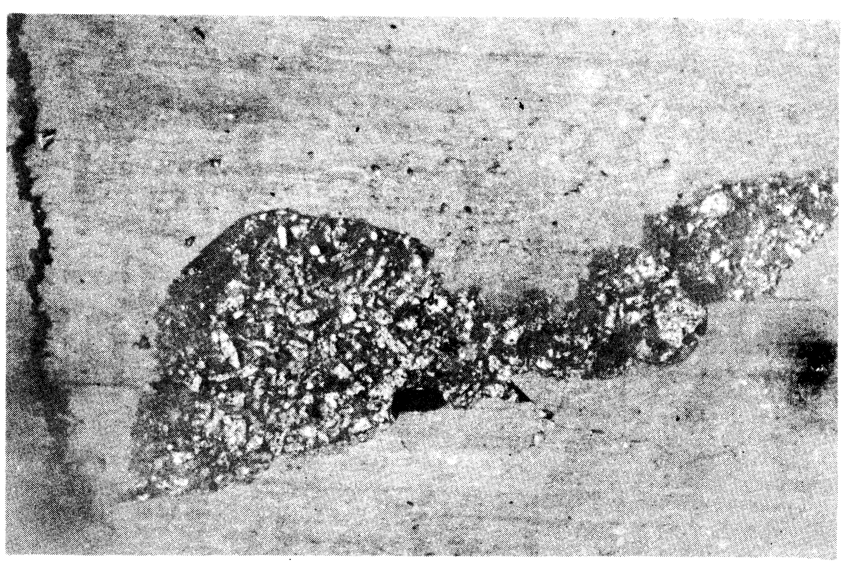

Figure 5. Large spalled area.

RECOMMENDATIONS

1. It is recommended that measures be initiated to arrest and repair the deterioration on the reinforced concrete culvert on I-77. Structural repairs may be considered, but at the least, the corrosive water should be neutralized to reduce the chemical deterioration. The injection of a lime slurry is a possible solution.

2. It is recommended that in future construction of concrete on which water from a nearby source, such as a spring, has ready access to the overlaying straw, an alternate method of backfill be used instead of the straw or imperfect trench method.