TECHNICAL SUMMARY

Cathodic Protection of Culverts-Field Application and Expert System

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INTRODUCTION

Louisiana uses metal culverts throughout the state for drainage purposes. Culverts made of concrete are also used, but large concrete culverts are more expensive and the foundation has to be able to bear their weight. However, the use of metal culverts creates problems associated with corrosion in environments with low ph and resistivity values of soil and water.

Until now, no attempts have been made to apply any corrosion mitigation methods to these metal culverts. They are simply replaced after failure occurs. To protect these buried culverts completely, both internal and external cathodic protection should be employed. A sacrificial anode system using magnesium or zinc anodes could be used depending on the environment.

In 1988, the Louisiana Department of Transportation (DOTD) funded its first project involving the use of cathodic protection on coated culverts. Eight different types of coated steel culverts were located in low resistivity soil and water for a period of five years. One set of the culverts received cathodic protection and the other set did not. Zinc anodes were used both internally and externally in the low resistivity environment. It was concluded from this work that any coated culvert could be protected by cathodic protection.

As an extension of this work, in 1996 the DOTD funded the current study to apply the technology of cathodic protection in the field to an existing culvert and to a new culvert before installation. These installations would provide the information necessary to establish the economic feasibility of using cathodic protection and to reveal any problems that would be associated with such an installation.

From this information, an expert system could be developed which would provide the state with information such as the economics of each culvert cathodic protection installation.

OBJECTIVES

The primary objective of this research was to achieve the following:

1. To install and monitor cathodic protection on a previously installed 10 foot diameter bituminous coated galvanized steel culvert system at the 122-mile marker on I-49. The system consisted of three parallel culverts that were each 360 feet long.
2. To install and monitor cathodic protection on a new culvert installation on Highway 757 in Eunice, Louisiana. The bituminous-coated galvanized steel culvert was four feet in diameter and 60 feet long.
3. To use the above information to develop an expert system in Visual Basic which will provide the user with information about the economics and installation of a cathodic protection system and a generic procedure for the installation of the anodes. The expert system also contains a Technical and User's manual.

CONCLUSIONS

The cost of retrofitting existing culverts at the 122-mile marker on I-49 was $25,863. Three feet of mud had to be removed from inside the culverts at an additional cost of $13,000. The cathodic protection system is working well on the external side of the culvert. The magnesium anodes are being consumed at a rate of 55 lbs./year, which equates to a cost of $275/year. Due to internal coating damage over the 12 years of field exposure, the internal cathodic protection is not working. Had cathodic protection been installed initially on the culverts, it is likely that the galvanizing would have remained, and the internal coating would have been in better condition. The potential inside of the culvert is a strong function of the water rate.

The cost of installing the cathodic protection system at the Eunice, Louisiana, site on Highway 757 on the 60-foot long, four foot diameter culvert was $3,495. The external potential shows that the culvert is protected at a potential more negative than -1.3 Volts. The current demand on the outside of the culvert is steady at 0.22 amps, which corresponds to a magnesium consumption rate of 4 lb/year or $20/year of cost. Internal cathodic protection appears to be working in this system since the potentials are more negative than -1.1 Volts. This is the potential required to keep the zinc from corroding and removing the coating.

A cathodic protection expert system has been developed which uses culvert and environmental information to predict the life of the culvert in the field. The California average life chart is used to estimate the corrosion rate. The pounds of internal and external anode material are calculated based on the efficiency of the coating. The material and labor costs of the cathodic protection installation is estimated by the program as well as the number of days required for installation. A generic procedure is provided by the program to assist in anode installation.

RECOMMENDATIONS

Whenever the culvert life predicted by the new expert system is less than that required by the DOTD, cathodic protection should be considered. The results of this study have shown that any culvert structure can be economically protected from external corrosion and that a new culvert can be successfully protected by an internal cathodic protected system. In the case of retrofit culverts, a thorough examination of the condition of the internal coating is required before internal cathodic protection is attempted. Excess coating damage may make internal cathodic protection impractical.

First consideration should be given to interstate culvert systems that are not likely to last more than 70 years in the soils of the state. Replacement of these culverts would be extremely costly. Culverts that do not have standing water would be good candidates for external cathodic protection only. This would reduce the cost of the cathodic protection system.

In an earlier cathodic protection feasibility study, it was apparent that a polymer coated galvanized steel culvert required less cathodic protection current than the bituminous coated culverts. A field study should be performed to verify this fact. This might assist thestate of Louisiana in the selection of the proper coating to be used in conjunction with cathodic protection. This would be especially helpful in the harshest environments where corrosion rates are high.

IMPLEMENTATION STATUS

The results of this three-year study have clearly shown that cathodic protection can be applied to both new and retrofit culverts. Since all metal culverts in the field will eventually corrode and collapse, it is recommended that cathodic protection be applied in cases where replacement would be more costly than applying cathodic protection. The new culvert system installation showed corrosion protection both internally and externally. However, on the retrofit system, cathodic protection worked externally, but excessive internal coating damage made it ineffective internally. It is believed that, in some cases, only external cathodic protection may be sufficient protection for culverts that remain dry most of the time.

The expert system developed from the data obtained in these field studies provides the economics needed to decide if cathodic protection should be applied to a new or retrofit system.