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New Product Evaluation
Interim Report
Report # WI-01-97

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New Product Evaluation
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by

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ABSTRACT:

The purpose of this study was to ascertain the viability of using slipliners to rehabilitate deteriorated corrugated metal culvert pipes under high volume roads in the State. The sliplining operation was to be considered as an alternative to the costly procedure of excavating and replacing the existing pipe.

In general this technology was found highly beneficial by the Districts who used the liners. Savings of up to 52% was achieved on one of the sites, when sliplining was compared with the conventional method of excavating and replacing the deteriorated culvert and pavement structure. This cost savings does not include those associated with traffic delays and interruption when excavating to replace the old culvert. Savings of more than 4% can be achieved, when the road is under reconstruction, and the pavement structure is excluded from the cost of excavating and replacing the deteriorated culvert. Greater savings are anticipated at greater depths. Inspection after three years in service revealed no significant deterioration in most liners. Monitoring of their long term performance is continuing. All the liners used, except Vylon by Lamson, were found to perform satisfactorily both during construction and in service. Vylon was found to be brittle and has questionable joint integrity. The use of Vylon in WisDOT projects in its present form is discouraged.

CULVERT PIPE REHABILITATION USING SLIP-LINERS

INTRODUCTION:

One of the effective ways to restore a culvert to a functional condition is by sliplining. Sliplining is a process of lining the culvert with either a conventional or specifically designed and prefabricated culvert product. The choice of the most appropriate lining material depends on the type, size, structural and hydraulic conditions of the existing culvert. It is also influenced by the site conditions, effluent characteristics, design and service life requirements and economic considerations, including the expected maintenance.

Some advantages associated with this process include, but are not limited to the following:

1. It allows the roadway to remain open to through traffic while the sliplining operation is in process.
2. It reduces the risk of settlement associated with removal and replacing deteriorated culverts.
3. It is a much faster process than excavating and laying new pipes.
4. With appropriate choice of lining material, it can eliminate the influence of environmental conditions that lead to the deterioration of existing culverts.

Sliplining has been practiced in the United States for many years [1-6], however, in the 1980's, this method was used predominantly on low volume roads. Use of sliplining techniques has been widened recently to include most types of roads in the country. Depending on the materials and techniques used, sliplining may restore the structural strength of a deteriorated culvert, and minimize the loss in hydraulic efficiency [5]. Although the lining process in most cases would reduce the existing cross-sectional area, most liners have lower Manning's roughness coefficient than existing corrugated culvert pipes. As a result, a proposed smaller and smoother liner may have equal or even higher flow capacity than an existing culvert once the water is in the culvert. This means that the proposed liner may provide improved "outlet control" conditions. However, it should be noted that "inlet control" may determine the culvert capacity, depending on the nature of the site and therefore needs to be investigated before a liner is selected. Simplified Manning's equation can be used to calculate the needed equivalent liner diameter that has approximately the same flow area as the original drainage structure. Such an equation is available in reference[6]. In addition, most liner manufacturers have tables showing liner internal diameters that will give equivalent flow capacity for a culvert pipe it is expected to rehabilitate.

In 1993, The Wisconsin Department of Transportation (WisDOT) sought out slipliner manufacturers to discuss rehabilitating many deteriorated aluminum culverts under high volume roads. Most of the corroded culverts identified for sliplining were aluminum culverts located in the acidic soil regions of the State. In

the spring of 1994, WisDOT, decided to evaluate various diameters of slipliners in the central part of the state, on STH 82 and USH 51, in Juneau County and Marathon County respectively. Eleven culverts were chosen in Juneau County, six of these were lined with polyvinyl chloride (PVC) "Vylon" while the remaining five culverts were lined with high density polyethylene (HDPE) "Culvert Renew" liners. In addition some culverts were lined with "Sclairpipe" in Marathon County, while others were lined with "Driscopipe" 1000, both Sclairpipe and Driscopipe are made of HDPE. The exact number of Sclairpipe and Driscopipe lined in Marathon County is not known. Sclairpipe was also used in several locations in Jefferson, Waukesha and Milwaukee counties located in the southwestern Wisconsin. "Hancor" (Hi Q) high capacity smooth interior was used in the western Wisconsin on STH 121, Jackson County, for lining an existing 1050 mm (42 inch) pipe

This report discusses some of the liners mentioned above. Included in the report are methods of their installation, associated installation problems and cost savings achieved. Liners that found favor with the district personnel in terms of ease of installation, cost savings, durability over time and good performance record are identified and recommended for use in WisDOT projects.

PROJECT LOCATION AND PRODUCT INSTALLATION

"Driscopipe"

The project where this product was used is located on USH 51, between Wisconsin River Bridge and CTH "K" in Marathon County. The existing pipes to be lined were identified at different locations along this project length. Their diameters range from as low as 350 mm to as high as 1200 mm (14 inch to 48 inch). The Driscopipe slipliner was manufactured by Phillips Company Inc, Richardson, Texas.

The installation procedure for this slipliner can be summarized as follows:

Initially the existing deteriorated culvert pipe was cleaned using a water jet, and the inside surface allowed to dry before the lining operation began. The liners were brought to site in 12 m (40 ft) segments. These were then joined together by fusion. This method was selected by the contractor since no particular method of joining the pipes was specified. The liner was then laid out, properly aligned with the existing culvert and pulled into the culvert by means of a chain tied round the liner and attached to a backhoe. After the liner was placed properly inside the culvert, it was trimmed to the required length with a chain saw. The end areas between the new and old pipes were capped on both ends with concrete grout. The space between the liner exterior and existing culvert interior (annular space) was then pressure grouted until most air spaces were filled with grout. This was achieved by inserting two small pipes at one end, one pipe was used for pumping the grout while the other served as air vent.

High Density Polyethylene (HDPE) And Vylon

The project is located on STH 82, from STH 80 to Mauston in Juneau County. Eleven sites were selected on this project length. Six sites were selected for PVC "Vylon" manufactured by Lamson and five sites for High Density Polyethylene (HDPE) "Culvert Renew" manufactured by Poly Systems, Inc. Renew culvert liner was in diameters of 450 mm (18 inch) and 750 mm (30 inch) and a total length of approximately 141 m (430 ft) were placed. Vylon Culvert Liner was in diameters of 450 mm (18 inch), 600 mm (24 inch), 750 mm (30 inch) and 1050 mm (42 inch) and approximately 154 m (470 ft) of these were placed.

Installing " Vylon"

Prior to the installation of the slipliners the old culvert was cleaned using the water jet as previously described for Driscopipe liners. The liner was then placed in the channel and pushed forward. A 400 mm (16 inch) insertion ring was positioned between the backhoe and the liner to distribute the load and avoid chipping the trailing end of additional Vylon section. Insertion rings were cut from each of the diameters used to aid installation of the Vylon slipliner. After insertion of each section of the liner pipe, the joint and gasket were thoroughly cleaned and lubricated with a special lubricant supplied by Lamson Vylon Pipe. The previously inserted pipe was then held in place and the next pipe section joined using gasketed joint system. This procedure was repeated until the entire culvert length was lined. The space between the old culvert and the new liner was subsequently pressure grouted as previously described.

Installing "Culvert Renew"

HDPE "Culvert Renew", utilized Thread-Loc joints making the assembly easy. As discussed previously, the existing pipe was cleaned with a water jet. Renew was then aligned with the pipe to be lined and pushed into the pipe using a backhoe or manual labor, until the section was exposed two to three feet. The second section was supported properly to maintain adequate alignment and then twisted manually through the threads until it fitted tightly. The liner was then pushed into the existing pipe and a third section fitted as described. When the required length was achieved, the extra length of the pipe was cut off with a chain saw. The space between the old culvert and the new liner was then pressure grouted.

OTHER SLIPLINERS

Other slipliners currently in use in the State include;

"Snaptite", manufactured by Irrigation Supply Co. and "Hancor", manufactured by Hancor Inc.

These liners are made of high density polyethylene material. Their method of installation was not documented on site, however it did not differ greatly from the procedure described for Culvert Renew. In general, installation of these liners follow the procedure outlined below[6] with minor modifications as indicated by the manufacturer.

1. Divert and/or control the water passing through the existing culvert
2. Clean and make any necessary repairs in the existing pipe
3. Construct or provide a guide way on the invert of the culvert to facilitate the sliplining of sections into the existing culvert
4. Install segments of the liner in the culvert by sliplining and connect them together using the most appropriate method for each slipliner
5. Grout or seal the space between the liner and the existing culvert. Check that the annular space has been completely grouted. Some types of slipliners may not require complete grouting of the annular space
6. Where necessary, modify or construct head and wing walls

When flexible pipe is used as a liner, it is important that the contractor does not use excessive grout pressure otherwise the liner pipe may buckle. Allowable grout pressures, which varies with the pipe diameter, are usually supplied by the manufacturers. In addition, different manufacturers do have specific restrictions on how the liners should be installed. It is necessary to consult each manufacturer for more details prior to installation..

DISCUSSION:

In general the Districts and Counties who used these slipliners found the technology highly beneficial. County forces and the WisDOT District Maintenance Section inspected these liners in service for a period of three years and found no significant deterioration in most of the liners. All the liners inspected, except Vylon, appear to be performing adequately for their intended use. Some minor erosion at the outflow of some of the slipliners was detected, and this was attributed to inadequate modification of the wing walls and channel bottom.

The cost for sliplining a 750 mm (30 inch) diameter pipe , and 61 m (200 linear feet) in length under a 4-lane roadway with approximately 1.5 m (5 feet) cover was compared with replacing the same pipe with a metal culvert, backfilling and replacing the pavement structure. It was found that sliplining is 52% less

expensive than replacing with a metal culvert pipe. If the road is under reconstruction, implying that the cost does not include the base course and pavement restoration, then sliplining is about 4% less. This is just the construction cost and does not include other intangibles such as costs associated with detouring the traffic so as to install a new pipe, or costs associated with other traffic delays and the potential for accidents. This cost comparison was based on a cover of 1.5 m (5 feet). As the cover depth increases, the excavation cost increases dramatically because of more complex excavation procedure for higher depths.

Also lining will provide better riding surface than replacing with a new culvert pipe, since the impacts of differential settlement and potential frost heaving will be eliminated.

It was difficult to obtain competitive bid prices for pressure grouting, and in some areas, grouting equipment for short term use was scarce. More economical grouting alternatives should therefore be investigated.

Performance of the individual product type shows that Vylon did not perform adequately. Vylon, made of PVC, is brittle. During handling and transporting to site in Juneau County, one of the joints broke and during installation, Vylon's blunt lead edge slipped against a steel rivet and cracked. The workers found pushing the Vylon through the existing pipe more practicable than pulling it. Also, during the lining and grouting operation, it was noticed that one of the joints separated. In the opinion of the workers, Culvert Renew was much easier to install than Vylon, and could withstand the site installation hazards much better. Inspection of the liners after three years in service also shows evidence that one of the joints in the Vylon had separated. No problems were detected on either the "Driscopipe" or the Culvert Renew.

Snaptite and Hancor were not studied directly in this investigation. However, reports from the District Maintenance Staff indicates that these materials have performed well in service. Hancor was rated as being of lower quality polyethylene, but was found adequate for the intended purpose and cheaper than Culvert Renew in areas where it could be used. It's thicker wall thickness may, however, make it impracticable in some sliplining situations.

CONCLUSION

Sliplining culverts is a viable, relatively inexpensive and minimally disruptive alternative to replacing deteriorated corrugated metal culvert pipe, provided the reduction in cross sectional area is acceptable hydraulically. In general, most of the lining materials inspected were found to be performing adequately after three years in service. However Vylon was found to be brittle and more difficult to install. It required greater care while handling and transporting. It's joint integrity

was also questionable. Hancor and Snaptite performed satisfactorily in service, however problems associated with their installation were not documented.

RECOMMENDATIONS:

The following interim recommendations are made and are intended to offer some early research guidance. Several years of additional data are needed before final recommendation can be made:

- Sliplining of deteriorated corrugated metal culvert pipes, where feasible, should be encouraged, provided that the hydraulic efficiency of the liner can restore the structure's flow capacity adequately.

- So far most of the liners in use appear to perform satisfactorily, except for "Vylon" which is brittle and has questionable joint integrity. The use of this product in its present form is discouraged in WisDOT projects.

- To reduce the cost of grouting, more economical grouting alternatives need to be investigated.

- As new, and possibly improved liners become available, the sliplining alternatives should be re-evaluated and a more detailed cost comparison undertaken.

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