Government Agencies and Others Reduce Costs By Sliplining

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Abstract

Culvert rehabilitation by sliplining has experienced increasing use throughout Canada. The increased usage is due to higher traffic density, social and environmental impacts and high construction costs associated with open-cut techniques.

This paper will explain the benefits of sliplining an existing culvert as well as the features the designer/installer should look for in a liner. Culvert sites that are suitable for this type of Trenchless technology will also be explored. Additionally, several culverts sliplining projects recently completed in Canada will be covered with emphasis on the design and construction issues.

Introduction

In January 2006, the residents and visitors to the Bancroft area took little notice to the culvert rehabilitation work that was occurring along Hwy 62. While the motoring public and truckers traveled this important highway, a contractor was busy rehabilitating a corroded 1950mm Corrugated Metal Pipe (CMP) culvert for the Ontario Ministry of Transportation (MTO). Prior to actual construction, the local MTO office evaluated several construction options before they eventually decided to rehabilitate the deteriorated CMP culvert by utilizing a trenchless construction process called “Sliplining”. The sliplining method was deemed to be the least disruptive from a social and environmental perspective as well as the most cost-effective one.

Sliplining a deteriorated culvert with a new culvert/liner often offers lower direct (e.g. overhead, construction, reinstatement costs and property damages) and indirect costs (e.g. traffic disruptions, repair costs, business loss, noise disturbance and service life reduction) than the more traditional “open-cut” construction method. Dr. John W. Heavens (Technical Secretary of the ISTT) states “When you include social costs such as time losses and accidents, which are frequently twice as high as direct costs, the trenchless method (referring to all types) nearly always has the lowest costs and is the most environmentally responsible choice.” (1). Another study on trenchless vs. open-cut methods has shown that social costs (indirect costs) on some projects can account for up to 400% of construction costs (2). The cost savings of sliplining becomes most apparent when the distressed culvert is either buried deep (Figure 1), under a high volume road or where trenching would cause extensive traffic disruption.

Figure 1: Culvert slipline in deep fill

Culvert sliplining restores the hydraulic and/or structural integrity of the existing distressed culvert. The sliplining process is one of the simplest ways to extend the service life of the host culvert. The steps involved with sliplining an existing culvert are:

1. Inspect and clean the host culvert;
2. Determine the appropriate new culvert/liner;
3. Prepare work area at one (or both ends) of host culvert for assembly of new culvert/liner;
4. Insert grout and vent tubes (or standtubes) as required;
5. Assemble and insert new culvert/liner in to host culvert;
6. Once new culvert/liner is installed, build a bulkhead at each end of the host culvert;
7. Grout annular space between host culvert and new culvert/liner with cementitious grout;
8. Restore and clean-up project site.

<u>Liner Selection</u>

One of the most important factors for a successful culvert sliplining project is liner selection. The new culvert/liner should have a smooth outer wall for easy insertion, be made from high impact resistant material to prevent it from being damaged during handling and installation, and have a fully restrained joint system to facilitate a push and/or pull installation. Since most of the culverts being replaced or rehabilitated are failing concrete pipes or corroded corrugated metal pipes, the new culvert/liner should be corrosion resistant and have excellent abrasion resistance. The resulting benefits will be lower maintenance costs and longer service life for a lower life-cycle cost. Where the new culvert/liner will be exposed to aggressive water, corrosive soils and/or road salts, a plastic (or other resistant) liner is recommended. The new culvert/liner should have a smooth interior surface to minimize flow capacity loss and to reduce the potential for silt, sand or gravel build-up for lower maintenance costs. The joint system should be easy to assemble while maintaining a constant outside and inside diameter (Figure 2). If the new culvert/liner will extend beyond the host culvert and be exposed to sunlight, a UV resistant one should be chosen. Some new culvert/liners with a lightweight construction allow for longer lengths and also enable the use of light-duty lifting equipment for lower construction costs.

Figure 2: County of Haliburton installs Weholite® to rehabilitate an existing CMP

<u>Design Issues</u>

Once the liner material (e.g. High Density Polyethylene (HDPE)) has been selected for its constructability and resistance to environmental factors, the designer must then determine one that is suitable to resist external loads. A conservative approach is to select a liner based on a "stand alone" condition and anticipated grouting pressures. A "stand alone" liner assumes the host culvert will not provide any structure support sometime during the service life of the liner and so it must resist all loads (dead loads, live loads, hydrostatic pressures). Where the invert of the original culvert has deteriorated, but the load carrying capacity has not been significantly diminished, the strength of the liner is more dependent on a determination of potential grouting pressures and the need to withstand handling and installation stresses.

The appropriate size of liner is one that maximizes the flow capacity of the original culvert, while keeping the amount of grout required to completely fill the annular space to a minimum. The maximum exterior dimension of the liner must take into account the offset joints, bends and other disturbances in the bore of the distressed culvert to ensure it can be inserted with relative ease. A good rule of thumb for sizing the liner is to select an exterior liner diameter that is 5-10% less than the interior diameter of the host culvert. To ensure that there is adequate space to fill in the annular space with grout, at least 1in. space on all sides of the liner is desirable.

The new culvert/liner should be grouted the full length of the existing culvert. This will provide a more secure attachment for the liner to the existing culvert, fill any voids created by previous washouts, give additional structural support and prevents point loading when the existing culvert eventually fails. The method of introducing the grout to the annular space can either be gravity fed (Figure 3) or pumped through a hose or small diameter pipe laid in between the liner and host culvert (Figure 4). When the lining is fairly long (100ft or more), the gravity fed method is not recommended for additional openings in the top of the existing culvert would be necessary for intermediate insertion of grout.

Figure 3: Grouting by gravity flow through a tube

Figure 4: Pressure grouting

The grout types that have been used on culvert sliplining projects vary by specifer, contractor, grouting method employed and availability. Ideally, the grout should be a low-density foam concrete consisting of Portland cement, fly ash and additives. This type of grout mix should allow the grout to flow easily and completely fill the entire annular space around the liner. At one particular sliplining project for MTO, the grout was specified as follows “Grout shall be 1:3, cement to sand ratio, with super plasticizer, high range water-reducer with a 250mm slump and achieve a 28-day compressive strength of 15 Mpa."(3)

Construction Issues

Sliplining an existing culvert is usually simpler and has less adverse effects on the surrounding environment than trench construction. A typical culvert sliplining project may take 4 to 5 days to complete with minimal impact on traffic flow, sensitive streams and fish habitats as well as lower use of natural aggregates such as earth and asphalt. When the host culvert to be rehabilitated is long or problems are expected with the insertion process, pulling heads are sometimes used. They can either be a fabricated mechanical pulling head or a field-fabricated pulling head. The mechanical pulling heads will usually have a conical shape that enables the liner to glide over offset joints or irregularities in the existing culvert (Figure 5). For HDPE liners, a less sophisticated but cost-effective approach is to fabricate a pulling head out of a few extra feet of liner. The leading edge of the HDPE liner has evenly spaced wedges cut out and the remaining ends are collapsed towards the center and fasten together with bolts, threaded rods or metal straps and attached to a cable (Figure 6).


Figure 5: Fabricated mechanical pulling head


Figure 6: Field-fabricated pulling head

In some culvert sliplining applications, guides are anchored to the existing culvert to fully support the liner at specific line and grade. When the liner size is large (greater than or equal to 48" Inner Diameter), the liner may be blocked and/or supported to prevent it from floating during the grouting operation (Figure 7). The pressure applied to the liner from the grout should not exceed the maximum specified grouting pressure for the particular liner. If the anticipated grouting pressure will exceed the limits of the liner, the grouting operation should be performed in multiple lifts.

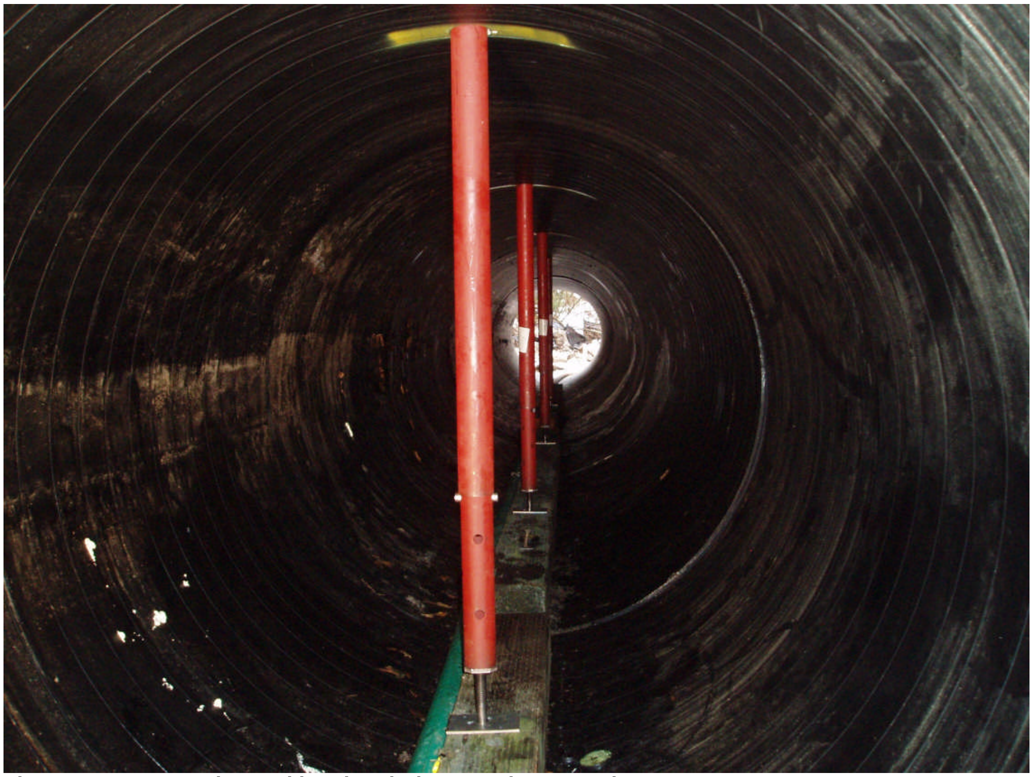

Figure 7: Temporary internal bracing during grouting operation

To contain the grout in the annular space during the grouting operation, bulkheads are built at each end of the existing culvert. These bulkheads can be made by placing a sufficient amount of aggregate or dirt at the culvert end, grouting only the first 1 to 2 metres of annular space from the culvert end or build suitable formwork at each culvert end (Figures 8 and 9).

Figure 8: Dirt bulkhead

Figure 9: concrete bulkhead

Once the grout and vent tubes (or standpipe) and bulkheads are completed, the annular space is filled with grout. If multiple grout lifts are needed, each lift should be allowed to set before continuing with the next lift. Repeat grout lifts until the annular space between the liner and host culvert and surrounding voids are completely filled.

Summary

Culvert sliplining is gaining acceptance throughout Canada and the world. Just recently the Quebec Ministry of Transportation (MTQ) approved Weholite®, a closed profile wall HDPE piping product to rehabilitate all of the culverts within their jurisdiction.

In addition, some municipalities are now considering the trenchless technology on road-widening projects. Instead of replacing the distressed culverts, they slipline them and extend the liner/culvert to accommodate the widening of the road. The results are projects that are less disruptive to the public and more cost-effective.

The sliplining approach to rehabilitate deteriorating culverts will, in most situations, result in lower construction, social and environmental costs for the project. This is especially the case when the distressed culvert is either buried deep, under a high volume road or where trenching would cause extensive traffic disruption.

The type of liner utilized is an important part of culvert sliplining for it determines its constructability and the longevity of the rehabilitation efforts. The liner should be resistant to all environmental factors to obtain a long-term solution to one's culvert problems.

References

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