Culvert-Slip-Liner Repair Method

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There are certain criteria that should be met when using the liners in lieu of open cutting and replacing with standard pipe.

1. **Scouring**: A location that is known to have scouring may be an ideal location for a liner. Liners are highly resistant to scouring. Tests are being conducted by the Materials & Tests Department of INDOT to determine the longevity of the liner when subjected to scouring.

2. **Acid Conditions**: Parts of Southwestern Indiana have extensive coal mining causing acidic conditions from sulfuric acid. Also there is run off of fertilizers and chemicals from farming operations which may cause acidic conditions. Most liners are not effect by acids. You may need to check with the manufacturer to see if your liner is acid resistant.

3. **Deep Fill Sections & High Traffic Volumes**: In some locations there are deep fill sections under the roadways. Some fills are as much as 80 feet deep. Excavating these areas to replace the pipe would not only be extremely expensive, but almost impractical. Also any inconvenience to the travelling public must be considered in any type of pipe replacement that would require a closure of the roadway. Liners may be installed without any type of road closure or lane restrictions.

4. **Resurfaced Roads**: Although all bad pipes on a road are to be replaced prior to resurfacing, INDOT is not infallible. The travelling public looks unkindly toward having the roadway cut anytime soon after a resurface. Therefore liners may be used on this merit alone because the roadway does not have to be open cut.

5. **Cost Effectiveness**: The cost of installing a liner can be competitive when compared to open cutting the roadway and replacing with standard pipe. I will show some cost comparisons later in the presentation.

**OTHER CRITERIA**

These are the main criteria we use when selecting locations for liners. However other criteria is used before final selection is made. The existing pipe must have retained most of its original shape and straightness or the liner will not slide through the existing structure. The pipe must be clean or have the ability to be cleaned. If the pipe is not clean the material will collect in front of the liner causing it to be wedged against the top...
of the existing pipe and becoming stuck. You must have a work area of approximately 25 feet long at either the inlet or outlet of the pipe so the liner may be placed in a trench and pushed. Although most of the liners can be manufactured in various lengths, it is best to try to use lengths around 20 feet long. Some liners have milled ends. The ends are expensive to manufacture. Therefore, the shorter the lengths the more expensive the liner will be. Liners over 20 feet in length may become too heavy or bulky to handle, especially in the larger sizes. These are the additional criteria used when selecting locations for liners.

**TYPES OF LINERS**

After selecting the appropriate location for liner replacement then comes the task of selecting the proper liner for your application. There are many types of liners that may be used including high-density polyethylene, both solid and profile wall, PVC, and profile wall polyvinyl chloride.

There are different types of joint configurations. There are; screw type joints, bell and spigot, grooved press on joints, and thermal welded joints. However there are some concerns with each type of joint.

**Screw type:** If the liner is large it is hard to get the ends matched up and to turn the pipe to screw the joint together.

**Bell and Spigot:** If while pushing the liner the liner becomes stuck it is very difficult to pull the liner out backwards.

**Grooved Press On:** The ends of these liners are very expensive to mill. If short pieces of liner are needed then it becomes cost prohibitive to use.

**Thermal Weld:** The ends of these liners need to be shaved so that the ends will match for the welding process. There is concern by some that these shavings will be eaten by wildlife.

In house maintenance crews prefer either the screw type or grooved press on joints. With the Bell and Spigot joint there is fear that the liner will become stuck and they will not be able to pull the liner out. The maintenance crews do not have a thermal welding machine or any experience with thermal welding therefore the thermal weld joints become impractical. However a contractor has the option to use any joint he prefers as long as it meets INDOT specifications.

**SIZING OF LINER**

The liner must be sized so that the flow is equal to or greater than 100% of the flow of the existing pipe. Because of the smooth interior of the liner the same flow can be met with a
liner smaller than the original pipe. If possible we use the largest liner possible to do the job. In some cases liners have been installed that are capable of 125% or more of the original pipes flow. This allows the original pipe to be lined a second time if and when the first liner goes bad. By using the largest possible liner the first time we can still maintain 100% flow with the second liner. By using a second liner we feel we can go at least 100 years without open cutting the roadway.

INSTALLATION

After the appropriate location and liner is selected then comes the task of installing the liner. An easement to get on an adjoining property may be necessary if there is not enough right-of-way to perform the installation. Most property owners will grant the easement when faced with closing their road for an extended period of time for pipe replacement.

It is best to install the liners from the inlet end. This will allow gravity to help with the pushing. However if this is not possible then pushing from the outlet is acceptable.

The inlet and outlet elevation of the existing pipe should be determined. If there is very little fall then there may be concern over flotation. Flotation may occur when a much smaller liner is installed inside the existing structure and then grouted. The middle of the liner may float to the top. Flotation may be a problem when the elevation difference between the inlet and outlet elevation is small. This may cause the pipe not to drain or it may cause water to be backed up on right-of-way or onto an adjacent property owner. The solution is to fill the liner with water or to attach wood, plastic, metal or some other rigid type running boards to the top of the existing structure before installing the liner. Flotation is generally not a problem if the difference in the size of the liner and the size of the original pipe is less than 4 inches.

After the liner is installed the ends of the pipe need to be bulkheaded so that the annular space between the liner and the pipe may be grouted. If the difference between the liner and the existing pipe is small the ends may be sealed with oakum soaked in a water activated urethane sealant, Duracal or any other quick set concrete mix may be used. Larger spaces may require brick and mortar. The bulkheads should be at least 1 foot thick to be able to withstand the weight and pressures of grouting. Be sure to include grouting and vent pipes in your bulkheads. Be sure to allow the liner to stick out of both the inlet and outlet ends of the existing structure. This will allow the liner to be extended if the fill section or roadway needs to be widened at a later date.

GROUTING

There are several ways to install grout and vent pipes depending on how the grout is to be placed.

There are 2 basic types of grouting; gravity flow and low pressure pumping. Gravity flow may be used on short runs of liners, generally 80 feet or shorter. If the annular space is to be gravity flowed the grout and vent tube should be placed at the inlet end.
This allows gravity to work for you and air can escape as the grout is added. If the vent tube is placed at the outlet end the grout will fill the tube before the air is allowed to escape. To place the grout tube a hole is cut, a little smaller than the diameter of the grout tube, in the top of the existing pipe and a 6” piece of PVC pipe is placed over the hole. Duracal is then poured around the grout tube to hold it in place. The vent tube is placed in the top of the bulkhead. It is generally a 2” piece of PVC pipe. Grout is then poured in the PVC grout pipe from a mixer truck. This process is slow and messy. However since the maintenance crews do not have a pressure grout machine this is the preferred method. The grout pipe may be long this also helps by providing head pressure. After grouting, the grout tube is removed and the vent tube is closed off.

Pressure grouting is used when the length of the liner exceeds 80 feet. Again a grout tube and vent tube need to be placed. Generally the grout tube and vent tube are placed through the bulkhead. They are smaller in diameter and are usually left in place. This keeps them secure during the pressure grouting process. Pressure grouting may be done from either end. However the vent tube should be placed in the inlet end to allow air to escape. Again these tubes are sealed off. Pressures should not exceed the manufactures suggested limit.

There are some considerations when grouting. Again flotation of the liner may be a concern. Large elevation changes of over 5 feet may require special blocking at the outlet end to prevent collapse from the weight of the grout. This may also be avoided by grouting in stages. Grout may be placed in stages, allowing the first stage to set up before placing the second stage. This will reduce the weight of the grout.

It can not really be determined if the whole annular space has been grouted or if there are voids left after grouting. However grouting seems to be the best method for filling the annular space and INDOT feels it is necessary to avoid future dips in the roadway caused by a collapsed outer pipe. Grouting may also fill the voids caused by lost backfill from bad joints or holes in the existing pipe.

**TYPES OF GROUT**

There are several types of grout used: portland cement formulas, cellular concrete grouts, low density foam grouts and flowable fills. Portland cement formulas require pressure grouting. They are heavy mixes and do not gravity flow well. Again pumping pressures need to be kept below the manufactures recommended limits. Cellular concrete grouts are low-density grouts with compressive strengths of 75 psi to 500 psi. These grouts may be gravity flowed. Low-density foam grouts have a weight typically 20 lbs. to 80 lbs. per cubic foot. These usually require a special piece of equipment to make because of the foam additive. Flowable fills are available in both cellular and non-cellular forms. Their densities range from 80 lbs. to 120 lbs. per cubic foot. Their flow characteristics and strength must be analyzed to determine suitability. Depending on the flowable fill these type grouts may be gravity flowed. Below is some typical grout formulas:
Formula 1

2650 lbs. Sand
100 lbs. Portland Cement
400 lbs. Flyash
55-60 Gallons Water

Formula 2

395 lbs. Cement
79 lbs. Flyash
1421 lbs. Sand
27 Gallon Water
11.9 cu. ft. Preformed Foam

Formula 3

300 lbs. Cement
1500 lbs. Flyash
1200 lbs. Sand
156 oz Super Plasticizer
45 Gallons Water
Air Entraining Admixture to obtain 10% air

COSTS OF LINERS

Liners can be cost effective in many applications. Usually the deeper the fill the more cost effective the liners are. Liners are used in most applications on the interstate. Liners are also used where the roadway is concrete. With a liner there is no need to dig up the roadway and therefore there are no long road closures waiting for the concrete pavement to cure. Some liners can also be used in oval pipe applications. These liners are strutted with lumber to fit the existing structure. They are then pushed and grouted. Then after the grout sets the wood struts are removed. The liner then will retain its shape. However strutting does significantly increase the cost of the liner.

The following graphs show a cost comparison between the installation of liners and replacing with standard pipe. The figures shown are estimates and will vary based on type of pipe to be installed and the type of liner used. However the figures do give a general cost comparison. As can be seen from the graphs the deeper the fill the more economical it is to use liners.

(charts)
15 INCH DIAMETER PIPE (COST PER LINEAL FOOT)

Cover (in Feet)

Cost (in Dollars Including Labor)

- Std. Pipe Cost (ft)
- Liner Cost (ft)
18 INCH DIAMETERPIPE (COST PER LINEAL FOOT)
30 INCH DIAMETER PIPE (COST PER LINEAL FOOT OF PIPE)