

Annulus Void Fill Material for Rehabilitated Sliplined Culverts

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The Problem

Sliplining is a method commonly used to rehabilitate deteriorated culverts. In this method, a new pipe with a smaller diameter is inserted into the existing host pipe, and the annular space between the two pipes is filled with a grout material (Figure 1). The success of this rehabilitation method depends primarily on complete filling of the annulus void and maintaining the integrity of the hardened grout.

In recent years, ODOT discovered several sliplined culverts with annulus void spaces that were not completely filled. Such culverts experience distortion and settlement as well as reduced structural capacity. ODOT's specification (SS 837) requires complete filling of annulus voids with an appropriate cementitious grout. Field investigations of typical sliplined culverts in Ohio confirmed that the lack of complete annulus void filling (Figure 2) is not uncommon. This lack of filling is often not detected during construction and may not be noticed until several years later. Inferior filler grout properties were expected to prevent grouts from completely filling annulus voids. Currently, there are no commonly accepted test methods to verify that the annulus void has been completely filled with grout.

The ODOT Office of Hydraulic Engineering initiated this research project to investigate the reasons for incomplete filling of the annulus voids and to develop a solution to address the problem.

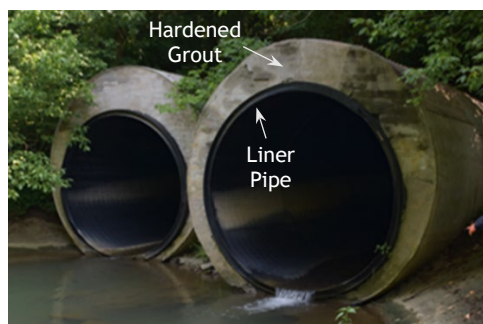


Figure 1: Typical Sliplined Culverts.

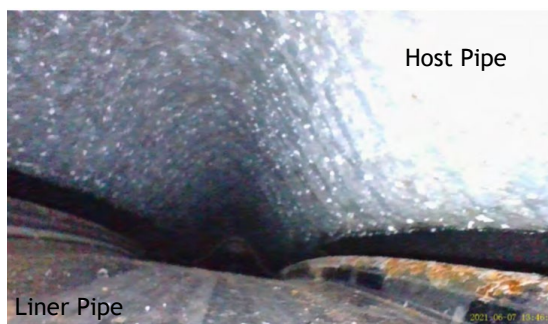


Figure 2: Image of the Inside of an Annulus Void that is Completely Empty.

Research Approach

The research team first gathered information on the state-of-the-art in terms of the materials and installation methods used for the sliplining of culverts and conducted a survey of the relevant stakeholders. Culvert inspections of more than 20 culverts in Ohio were performed using the sounding method (Figure 3). Non-destructive testing provided by Inversa System was also used as an alternative.

It was quickly confirmed from the culvert inspections that the lack of grout in the annulus voids of sliplined culverts (Figure 2) is a prevalent problem. The grout material properties, particularly poor flow characteristics, were suspected to be the primary cause of the problem. Therefore, void fill materials that are typically used in Ohio (standard and modified grouts) were identified, and extensive laboratory tests were conducted to study their wet and hardened grout properties. Two materials were finalized with improvements: a modified controlled low-strength material (CLSM) and a C40 cellular grout. Parallel

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plate structural load tests conducted on segments of the culvert test specimens confirmed that the presence of voids in annulus voids reduces the strength of the culverts. Prevention of voids at the crown position is most critical for maintaining the structural integrity of sliplined culverts.

Larger batches of the two improved grout materials were made in a commercial concrete batching plant, and field tests were then conducted to confirm that the two grouts had adequate flowability to allow pumping over long distances. Culvert test specimens that were 20 ft. long were prepared in the field using steel pipes grouted with both materials to verify that complete filling of the annular spaces can be achieved with the proposed grout alternatives (Figure 4). After the annulus void grout had hardened, the culvert test specimens were cut into four segments. The resulting cut surfaces demonstrated complete filling of the annulus voids over the entire length of the test culvert specimens (Figure 5).



Figure 3: Typical Hammer Test.



Figure 4: Culvert Grouting Test Setup.



Grout Inlet End

Findings

The culvert inspections performed in this project confirmed ODOT's suspicion that incomplete filling of annulus voids is a common occurrence for sliplined culverts in Ohio. While there are some limitations of the method, the hammer sounding method can still detect different types of annulus void anomalies and help skilled and experienced inspectors assess the conditions of the annulus behind the liner pipe wall for several liner types and fill materials. The use of volume-expanding admixtures is effective for producing a flowable grout that can be easily pumped and will be able to completely fill the annulus voids of culverts. However, neat low-strength material (LSM) grouts that incorporate cement and/or fly ash and no fine aggregates are not suitable for this purpose due to excessive shrinkage. Cellular grout C40 made with suitable foaming agents can satisfy the ASTM minimum requirements for wet and hardened grout properties and is suitable as an annulus void fill material for sliplined culverts.



Figure 5: Cutting of a Culvert for Annulus Void Inspection (Left); Cut Surfaces of Hardened Grout (Right).

Recommendations

Based on the findings of this project, recommendations were made for changes to the relevant ODOT specifications to include mixture proportions for both improved CLSM and C40 cellular grout. A list of standard test methods that must be used to verify fresh and hardened grout properties for these grout materials to achieve complete filling of the annulus voids of sliplined culverts is also recommended.

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