LESSONS LEARNED DURING SEWER REHABILITATION ON PUBLIC AND PRIVATE PROPERTY, CITY OF WESTLAKE, OHIO

Scott E. Belz, URS Corporation, scott_belz@urscorp.com
James J. Smolik, P.E. City of Westlake, Ohio
Robert P. Kelly, P.E. City of Westlake, Ohio
Anthony J. Blanc, P.E. URS Corporation
David G. McCallops, P.E. URS Corporation

ABSTRACT

In 1992, the City of Westlake, Ohio implemented an Inflow and Infiltration (I/I) program to eliminate excessive storm water from entering their sanitary sewer system during rain events. The goal of this program was to identify the sources of excessive water, develop a rehabilitation technique or repair for the problem. Four areas were investigated and rehabilitated. Each area used some similar rehabilitation techniques, however through the course of each project, certain lessons were identified from the testing, to the bidding and finally during the construction phase. The City modified their program in the subsequent phases based on the lessons learned in each previous phase. All of the different rehabilitation methods used reduced I/I and eliminated basement flooding. The four areas and year of completion are King James Subdivision (1992), Salem-Radcliffe Subdivision (2001), Berkeley Estates (2004) and Canterbury (2007).

KEYWORDS: Lateral Rehabilitation, Basement Flooding Reduction, Inflow/Infiltration Study.

INTRODUCTION

The City of Westlake, Ohio is located in northeast Ohio. The City is mostly residential with light industrial and retail areas. Population is approximately 34,000 people and the daytime population exceeds the nighttime. There are over 142 miles of sanitary sewer in the City. The City has its own engineering department that is responsible for design, bidding, contracting and construction inspection.

The topography is relatively flat with storm sewers installed at minimum slopes. During intense rain events, surface water flooding does occur in streets and yard. Intense rain events also cause the surcharging of sanitary sewers, which has been linked to basement flooding.

In 1992, the City implemented an I/I program based on flooding and other sewer problems. Since 1992, four (4) areas have been investigated by contractors or consultants. Each area used some similar rehabilitation techniques, however through the course of each project, certain lessons were identified from the testing, to the bidding and finally during the construction phase. The City modified their program in the subsequent phases based on the lessons learned in each previous phase. All of the different rehabilitation methods used reduced I/I and eliminated basement flooding, however some with varying degrees. Some of the lessons learned included Pre-rehabilitation techniques, Product selection, Engineering specifications, Engineering controls and Post-rehabilitation techniques.

The four areas and year of completion are King James Subdivision (1992), Salem-Radcliffe Subdivision (2001), Berkeley Estates (2004) and Canterbury (2007). All of the areas were built between the 1950's and 1970's, have separate storm and sanitary sewers and have had basement flooding. Some areas were septic tank conversions, where the septic tank was removed and reconnected to a new sewer lateral. Most storm drainage on private property has downspouts that drain to the storm sewer or a splash block.

METHODOLOGY

Prior to any sewer rehabilitation or repairs, a sewer investigation must be conducted to identify the types and location of defects in the sewer system. These investigations utilize different testing techniques that focus on both public and private property. Typically, Public property areas are where the sewer system is located in the Right of Way (ROW) of the street or easement and is the responsibility of the City and includes the mainline sewer and manholes. Private property areas are where the sewer system is located from the ROW to the house and is the responsibility of the homeowner and includes the laterals and cleanouts. Both of these areas have different sewer components that are susceptible to deterioration, decay and malfunction.

For all of the projects undertaken by the City of Westlake, either contractors or consultants conducted the testing as part of the sewer investigation. Testing for all of the project areas included some or all of the following testing methods:

- Flow Monitoring
- Groundwater Monitoring
- Mainline Dye Testing (Public)
- Residential Dye Testing (Private)
- Sanitary Manhole Inspection (Public)
- Closed Circuit Television Inspection (Public)

Once the testing was complete, a detailed report was submitted to the City with recommendations for rehabilitation or repairs to the system based on the best engineering judgment at the time of the report. These reports included recommendations for mainline sewer lining, lateral lining, manhole sealing, grouting, and capping cleanouts. After the reports were submitted to the City they were reviewed and finalized. From the reports, the City engineering department took the recommendations and developed engineering documents for Bid and Specification for the specific rehabilitation that was recommended and the projects were let out for bid to contractors. The City provided the engineering, bid documents and construction administration for the projects.

RESULTS

KING JAMES SUBDIVISION

The King James Subdivision was the first area to be investigated and rehabilitated by the City. The sewer investigation for this area was conducted by a contractor and data was provided to the City as data with no engineering recommendations. This was the City's attempt to save costs and conduct the engineering recommendations with their own department. While engineering was completed internally, the contractor data report lacked the backup and details of the testing which is commonly provided by a consultant.

Testing in this area was focused on Public property only. No flow monitoring was conducted for either post or pre rehabilitation monitoring. Testing consisted of mainline dye testing which included adding dyed water to the storm sewer system and looking for leaks into the sanitary sewer, then using a CCTV camera to identify the leak and its location. Manhole inspection was also conducted throughout the subdivision. From the testing results, a rehabilitation plan was developed and included the sealing of manholes and lining the sanitary sewer with a Cured in Place (CIP) sewer liner.

However, flooding problems still existed even after the rehabilitation. The City revisited investigating the area since the flooding problems were not solved. The City felt that the problems may lie on private property as well as public property. For the second phase, flow monitoring was conducted. This data was used as a baseline to measure I/I in the system and also for pre-rehabilitation monitoring data. All houses in the area (50 houses) were dye tested by adding dye to each downspout. Wherever dye transferred from the downspout of a house to the sanitary sewer, rehabilitation was performed on the house. Rehabilitation included exposing both storm and sanitary laterals and cleaning each of the laterals. After the cleaning was complete, both laterals were inspected for leaks and structural defects. When possible, point repairs were conducted and all of the laterals were grouted from the mainline sewer to the house. New cleanouts were then installed at each house.

The City was faced with who should pay for the new repairs which included work on private property. City council agreed that residents should pay for structural repairs outside the ROW and the City would pay for all work in the ROW and lateral grouting outside the ROW. The result was that only $5000 of the $338,000 for rehabilitation costs fell under the homeowner's responsibility (approximately 1.5% of the contract).

Lesson's learned from the King James Subdivision showed that both Public and Private sides needed to be addressed when completing sewer system rehabilitation. Work on the Private property was as beneficial to the program as the work on Public property. Flow monitoring prior to the rehabilitation is critical to determining the success of the project. The City also decided that all of the future rehabilitation work for these types of projects shall be 100% funded by the City.

SALEM-RADCLIFFE SUBDIVISION

The next area to be investigated was the Salem-Radcliffe Subdivision. The sewer investigation for this area was also conducted by a contractor and data was provided to the City as data with

no engineering recommendations. Downspouts on each house were tested and houses with positive dye transfer were listed for rehabilitation. For this area, a Cured-in-place (CIP) Sanitary Lateral Lining was utilized from the mainline sewer to the house. The CIP method used consisted of a felt liner with a polyester resin and steam curing. Lateral selection was based on downspout testing results with dye and a camera positioned in the sanitary main. A pit was used to expose both storm and sanitary laterals for cleaning and televising, sanitary lateral lining and installation of new cleanouts. Manhole Sealing was conducted using a spray applied polyurethane liner. Manhole selection was based on defects found during the visual inspection. Flow monitoring was also conducted after the rehabilitation. In addition, dye testing was conducted after the rehabilitation to verify that leaks were removed from the system

Lessons learned from the Salem-Radcliffe Subdivision showed that the liner was installed short of the mainline with the work not addressing the mainline sewer/lateral interface. This allowed groundwater to migrate down the lateral to the path of least resistance at the mainline/lateral connection. Storm mainline sewers should have been inspected and cleaned. In manholes that had the spray liner applied, the grade ring area was not sealed with a flexible product. This allowed groundwater to enter and led to the product cracking at the grade interface. Flow monitoring showed a reduction of 80% I/I in the area. Flooding complaints in the area also ceased.

BERKELEY ESTATES

Berkeley Estates was the first area to be tested by a consultant. Flow monitoring and groundwater monitoring were used to verify excessive water was entering the sanitary sewer. Both mainline and residential dye testing was completed in this area showing that both public and private property sewers were contributing to I/I in the system.

The same type of Sanitary Lateral Lining CIP process from the mainline sewer to the house was used for this area. The CIP method used consisted of a felt liner with a polyester resin and ambient curing instead of hot water. Lateral selection was based on downspout testing results with dye and a camera positioned in the sanitary main. A pressure launching vessel was used for the inversion and the lateral/main interface was grouted with a lateral packer. This ensured that groundwater wouldn't penetrate the seal from the lateral at the mainline sewer.

Manhole sealing was conducted using a cementitious product with a flexible urethane product at the grade ring. This was an improvement from the last project which did not use a flexible material. Prefabricated rubber membranes with expansive straps were also used in several manholes. Manholes with defects were selected from the visual inspection conducted during the testing. After the rehabilitation, flow monitoring was conducted to see if I/I was eliminated or reduced. Flow data did show that flows decreased during rain events. Post dye testing was also conducted to verify that the leaks were eliminated.

Lessons learned from the Berkeley Estates project showed that liner failures, possibly due to ambient curing or the resin introduction process impacted the ability to grout the mainline/lateral connection. This area was previously serviced with septic systems and records were not available on how they were tied into the mainline when they were converted. This resulted in the contractor sometimes needing to excavate two pits to expose both the storm and sanitary laterals which was not in the bid document. Storm laterals were difficult to locate due to lack data from

not televising the storm sewer prior to the repair work. The cementitious manhole lining product was also more cost effective to apply than the previous product.

The City found that testing requirements need to be established to verify that the liner met the performance strength requirements that were specified in the contract documents. Vacuum testing for manhole products also needs to be implemented on future projects. This project also showed that more research needs to be conducted during the design stage of the project, especially in identifying the pipe layout in septic tank conversions. Many branch connections were found during the excavation. Future testing during the investigation will try to identify if spot repairs can be conducted instead of lining the laterals. Testing also needs to be implemented at the mainline/lateral interface to be sure a tight seal is in place.

Flow monitoring showed a reduction of 95% I/I in the area. Flooding complaints were reduced or non-existent.

CANTERBURY AREA

The Canterbury Area was the most recent area investigated with a rehabilitation of the mainline sewers and laterals based on the recommendations of the investigation. Like Berkeley Estates, a consultant conducted the exact type of testing and provided an engineering report. Flow monitoring and groundwater monitoring were both used in this area.

Again, Sanitary Lateral Lining utilized a CIP process from the mainline to the house. The original CIP installation utilized a felt liner with a polyester resin and ambient curing. However, the resin was changed to epoxy because it was available domestically. The method of curing the CIP was also changed to re-circulating hot water to meet the performance specification of the product. All of the lateral selection was based on the positive downspout testing where leaks occurred. Similarly, a pit was used to expose both storm and sanitary laterals, lateral lining and install cleanouts during the lining procedure. If more than one pit was required, it was a bid item in the contract which protected the contractor since it would not be known until excavation if more than one pit was required. Laterals that had mineral deposits were not lined. These laterals were chemically grouted with a lateral packer.

Mainline grouting was completed in areas identified from the mainline dye testing results. Joint leaks found during dye testing were listed for grout. Grouting of interface was also completed between the sanitary lateral and the mainline sewer. Laterals that showed signs of infiltration or staining were also grouted as noted from the inspection.

Manhole Sealing utilized a cementitious product with a flexible urethane product at the frame/wall interface. This product seemed to work the best in comparison to previous products used.

Testing that was implemented on this project included pre- and post flow monitoring, pre- and post dye testing, vacuum testing of the manholes, air testing from the cleanout to the mainline sewer and physical testing of the CIP liner to verify strength parameters (Flexural Modulus and Flexural Strength).

Lesson's learned during the Canterbury Area focused on complications due to the houses being septic tank conversions. Many had branch connections and could not be lined. Some liners had to stop short of the house due to a 4" diameter reducer at the interface of the lateral and the house. Many problems were encountered during the construction project. Some laterals failed due to workmanship. Resin was not cured properly, not measured correctly due to faulty equipment, calibration bladders were pulled prior to curing or installed too short. In some instances, the liner was installed too short from the pit to the main. Other issues such as laterals that extended beyond 100 linear feet and around the rear of the houses made it difficult to estimate lateral lengths for the contractor. Some homes had downspout leaders which were compromised from roots and broken pipe which needed repair imposed on the laterals. Post flow monitoring has not been conducted for this project to know if excessive water has been removed, however, flooding complaints have been minimized.

CONCLUSIONS

Throughout all four of the rehabilitation projects, lessons were learned in each one and at different phases of the project from testing during the investigation to bid and specification items, to product specification and testing to construction methods and installation. Key items for each segment of the project are discussed below.

TESTING TECHNIQUES

During the residential testing, locating the exact source or potential location of the leak will assist the engineering judgment of recommending lateral lining or spot repair at a specific house. Altering the testing procedures to spend more time searching for the leak on private property rather than discerning if it was positive or negative may possibly eliminate the lining and associated costs. Televising the storm sewer during testing can prove if the storm sewer is correctly connected and if there is a direct connection or dye transfer. Televising the storm sewer also locates the storm laterals, reveals the condition of the storm mainline sewer and gives an overall assessment of the system.

BID AND SPECIFICATION ITEMS

By conducting rehabilitation on several projects, the overall bid and specification document improved at each project. Important items that protected both the City and the contractor were eventually included in the package. Specifically, number of cleanout pits, length of the lateral liners, how to deal with lateral branches, type of product and quality assurance testing requirements were all things that made important decision making points at various times of construction during the project and provided insight for future improvements. There is a need to pay attention to writing a very descriptive specification and providing clear detailed drawings when possible. It is important to include the proper testing procedures and requirements and hold the contractors and manufacturers to those requirements.

PRODUCT RECOMMEDATION

While several products were used on these projects, overall success was based on the cumulative effort of the product, installation and workmanship. Products that were successful were CIP liners which were felt liners with an epoxy resin with hot water curing. It is recommended that future liners that can be installed with a transition from 5" to 4". Chemical grouting was also successful on the mainline sewer joints, however long term exposure of the product has not been endured as this was only installed within

the last 5 years. Manhole liners worked much better with a flexible urethane grade ring than the rubber liners with straps.

CONSTRUCTION METHODS

One of the key lessons learned during these projects was the ability to find a contractor that has extensive experience in installing, testing and overall knowledge of the product limitations. Throughout these projects, different contractors were used and each with varying degrees of knowledge and competence which wasn't identified until the project was on-going or ended. With the advances in technology and new products being introduced to the market on an annual basis, it is important to find a contractor that has experience with a specific product. Additionally, a contractor needs to understand the differences and application of the various products as well as having the experience in different types of installation problems.