Today's presentations will cover:

**Perspectives on Manhole Rehabilitation**
Perspectives on Manhole Rehabilitation

The A, B, Cs Series

WEF CSC Committee

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Perspectives on Manhole Rehabilitation

The A, B, C’s Series

Webcast Sub-Committee Members
• Abraham Araya – Seattle, Washington
• Thomas Curl – The Woodlands, Texas
• Mattie A. Engels – Dallas, Texas
• Wes Frye – Nashville, Tennessee
• Chris Johnston – Burnaby, British Columbia
• Stephen A. Lipinski – Duluth, Minnesota
• John Nelson, Pewaukee, Wisconsin
• James J. Paluch – Elizabeth, New Jersey
• Tina Wolff – Fort Wayne, Indiana
Existing Sewer Evaluation and Rehabilitation

- WEF Manual of Practice FD-6
- ASCE Manuals and Reports on Engineering Practice No. 62
- 2009, Third Edition

Chapter 6 – Selection of Sewer Rehabilitation Methods and Materials

- OVERALL CONTENTS
  - Introduction & Overview
  - Rehabilitation Types, Materials, Methods
  - Pipeline Repair, Renewal, Replacement (RRR)
  - Manhole & Service Connection / Sewer Lateral RRR
  - The Selection Process
  - Quality Assurance / Quality Control
The A,B,C’s Series Continues

- February 2011: Manhole Repair, Renew, Replace
- June 2011: Service Connection / Sewer Lateral Repair, Renew, Replace
- November 2011: Pump Station / Lift Station Repair, Renew, Replace

Collection System Challenges

- Rehabilitation – repair, renewal, replacement – is a constant part of sewer management
- Financial limitations are forcing us to “do more with less”
- Good technologies are being eliminated from the rehabilitation tool box due to -
  - Poor applications of technology
  - Poor definition of conditions
  - Poor oversight
  - Poor communication
Key Ideas

• Be fully aware of the interrelationship between the owner, designer, contractor and manufacturer
• Understand the rehabilitative processes available to you
• Identify your specific conditions and select the best rehabilitative tool
• Apply appropriate QA/QC standards to protect your rehab investment

Manhole Rehabilitation
Speakers and Agenda

- Steve Henning
  - Importance of good condition assessment
  - Approach to inspection
  - Key aspects to rehabilitation
  - Rehabilitation products

- John Selvog
  - Defining success
  - Keys to a successful rehabilitation
  - Case Study: Menasha, WI
  - Step-by-step process review
Speakers and Agenda

- William Suchodolski
  - OCUA’s perspective
  - Scheduling & sequencing
  - Corrections for deterioration
  - Bidding
  - Quality control

Manhole Inspection and Rehabilitation Guidelines

Steve Henning
AP/M Permaform
800-662-6465
Manhole Rehabilitation
Process Overview

• Prioritize manholes to be inspected.
• Conduct standardized inspections.
• Determine manhole physical conditions.
• Choose appropriate repair technology or combination of technologies.
• Perform both field and laboratory QA/QC procedures as outlined in the bid document.
• Always perform all inspection and rehabilitation activities in a legal and safe manner.

Manhole Inspection Prioritization

• The manholes that have the most possible negative impact should be inspected first.
• The location of a manhole in the overall system directly influences the need for evaluation.
• The amount of flow through the manhole is extremely important.
Manhole Inspection

- Determining the number of manholes in your system.
- Dr. Vipulanandan with the University of Houston conducted a large scale survey that shows for every 100,000 residents a city will have very close to 6,000 manholes.
- This ratio works for cities of all sizes.

Close the Lid, We Were Never Here!
Inspection Guidelines

- NASSCO, the National Association of Sewer Service Companies, has developed a comprehensive, unified system for evaluating Manholes.
- The Manhole Assessment and Certification (MACP) program entails using only approved descriptors of conditions and certified software for recording defects when using video cameras.

Infiltration - Weeper (IW)

Note: Infiltration can be seen “Weeping” from joints beyond the camera position, therefore defects are coded as continuous.

<table>
<thead>
<tr>
<th>Distance (Feet)</th>
<th>Video Ref.</th>
<th>Code</th>
<th>Modifier</th>
<th>Continuation</th>
<th>Location</th>
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<td>S02</td>
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### Infiltration - Dripper (ID)

Note: Joint Column used as Modifier.

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<th>Code</th>
<th>Continuous defect</th>
<th>Value</th>
<th>Joint</th>
<th>Circumferential Location</th>
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### Infiltration - Runner (IR)

Note: Joint column used as Modifier.

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<th>Value</th>
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</table>
Infiltration - Gusher (IG)

Note: Infiltration from 08 to 09 are coded "Gushers".

<table>
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<th>Modifier/severity</th>
<th>Continuous defect</th>
<th>Value</th>
<th>Joint Circumferential Location</th>
<th>Remarks</th>
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</thead>
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<tr>
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<td>IG</td>
<td>S01</td>
<td>08</td>
<td>09</td>
<td></td>
</tr>
</tbody>
</table>

Now, Describe the Infiltration
Inspection Guidelines

• The MACP process allows for two distinct inspection processes identified as Level 1 and Level 2.
• A Level 1 inspection will allow utility owners to gather basic condition assessment information.
• Level 2 goes into much greater detail.

Inspection Guidelines

Safety, Safety, Safety

• It is imperative that OSHA, State, and local guidelines for confined space are being performed at all times when entering a manhole or similar structure.
• If you visit a site you should see: a fully functional gas meter monitoring the atmosphere, a confined space permit nearby and the entrant wearing a harness that is attached to the tripod.
• If that is not the case, you must immediately stop all operations, until these conditions are met.
Traffic Control and Bypass Pumping Safety Concerns

- Traffic control procedures must be closely followed.
- Signs and flagmen may be needed to sufficiently protect onsite workers.
- Bypass pumping presents many safety challenges, especially as flow rates are increased.

Rehabilitation Guidelines

- Manholes suffer a seemingly unending list of conditions that negatively impact the life of the structure.
- Traffic loading, freeze/thaw cycles, a very corrosive environment, abrasion, erosion, surcharging, and loss of support are just some of the conditions encountered.
Manhole Rehabilitation Clearly Defined

- The contract documents must clearly state the type of repair materials allowed, and the required thickness of all materials to be applied.
- The contract must also specify the components of the manhole that are to be rehabilitated.
- Benches and inverts may be specified separately from wall repair.

Properly Cleaning the Manhole Surface is Imperative

- Every manhole rehabilitation method, with the exception of chemical grouting, requires a cleaned interior surface.
- Manholes should be cleaned with water at a minimum pressure of 3,500 psi.
- Water infiltrating into the manhole is typically stopped before liners or coatings are applied.
Stopping Infiltration May Have Unintended Consequences

• When water that has been entering a manhole is no longer allowed into the manhole, there may be serious erosion problems created in or around the rehabilitated manhole.

Rehabilitation Product Guidelines

• There are a wide variety of products including cement mortars, epoxies, polyurethanes, polyureas, cured in place liners, chemical grouts and others used to repair manholes.
Rehabilitation Products
Chemical Grouts

• Chemical grouts may be used to stabilize the soil outside of the manhole to keep water from entering the manhole.
• Chemical grouts may be directly injected into cracks of precast manholes.

Rehabilitation Products
Cement Mortars

• Cement mortars are the most common repair products.
• They are used to stop infiltration and provide structural support.
• They are typically applied from .5 inches to 1 or more inches, determined by the manhole condition.
Rehabilitation Products
Cement Mortars

- Cement mortars can be hand applied, sprayed by hand or centrifugally cast on to the surface of the manhole.
- ASTM F-2551 *Standard Practice for Installing a Protective Cementitious Liner System in Sanitary Sewer Manholes* describes the installation process.

Rehabilitation Products
Cement Mortars

- Cement mortars are commonly used as a stand alone product.
- Cement mortars may consist of various materials or additives to increase corrosion resistance.
- Or serve as a structural liner that will have an epoxy or other coating applied on top of it for corrosion protection.
Cement Mortars
Perfect Application Example

Cement Mortars
Centrifugally Cast
Rehabilitation Products
Epoxies

- Epoxies are typically applied over a cement mortar liner.
- Epoxies are spray applied by hand or centrifugally cast.
- Epoxies are generally applied from 60 to 125 mils for corrosion protection.

Rehabilitation Products
Epoxies

- Epoxies may be applied at thicknesses up to 500 mils to serve as a stand alone structural product providing increased corrosion protection.
- A wide variety of epoxies are available to meet specific chemical resistance requirements as well as temperature or application requirements.
Rehabilitation Products
Epoxies

Rehabilitation Products
Polyurethanes and Polyureas
Rehabilitation Products
Cured in Place Liners

Manhole Rehabilitation Design Guide

• What is the most obvious problem with the manhole?
• Loss of structural support.
• Large amounts of infiltration.
• Highly corroded interior components.
• What are the consequences of total failure?
Manhole Rehabilitation Design Guide, Structural

• Manholes needing structural support can use cement mortars at designated thicknesses. Typically, ½ inch to more than 1 inch. Design guides available.
• Epoxies at thickness from 250 to 500 mils can provide structural reinforcement.

Manhole Rehabilitation Design Guide, Infiltration

• Methods for stopping infiltration include:
• Chemical grouts, injected into cracks or to stabilize soil outside of manhole.
• Cementitious plugs.
• Lining the entire interior: cement mortars, epoxies, polyurethanes, polyureas or cured in place liners.
Manhole Rehabilitation Design Guide, Corrosion

- Epoxies are used for increased corrosion protection.
- Cured in place liners are viable products for this application.
- Cement mortar anti-microbial additives.
- Polyurethanes and Polyureas are also used for increased corrosion protection.

Quality Control Field Techniques

- The best and most obvious quality control process is to watch the rehabilitation process as often as possible.
- Along with being able to observing safe practices, going to the work site on a non-routine basis can increase the end quality of the project.
Quality Control
Field Techniques

- Read the contract document to determine what specific processes are to be performed in the field, the frequency of the testing and the availability of the associated results.
- Make sure the proper tests are being performed by experienced personnel at a third party laboratory.
- Request the test results in writing.

General Pricing Guidelines

- Cement Liners $100.00-$160.00 per vertical foot, vft.
- Epoxy Coatings $120.00-$180.00 per vertical foot, vft.
- CIPP Liners $280.00-$450.00 per vertical foot, vft.
- Polyureas $120.00-$180.00 per vertical foot, vft.
- Polyurethanes $120.00-$180.00 per vertical foot, vft.

- These prices are to illustrate basic price ranges that do not take into account mobilization and demobilization, bypass pumping, traffic control or nonstandard conditions. A limited amount of repairs to be performed will also greatly impact pricing.
Manhole Rehabilitation Process Summary

- Always perform all inspection and rehabilitation activities in a legal and safe manner.
- Prioritize manholes to be inspected.
- Conduct standardized inspections.
- Determine manhole physical conditions.
- Choose appropriate repair technology or combination of technologies.
- Perform both field and laboratory QA/QC procedures as outlined in the bid document. Receive test results.

Questions?

- AP/M Permaform
  - 800-662-6465
  - Steve Henning
Questions?

Manhole Rehabilitation
Construction Perspective

John Selvog
Infrastructure Technologies, Inc.
Toll-Free 800-533-4244
www.infratechonline.com
Keys to a Successful Manhole Rehabilitation Project

Definition of a successful manhole project:
1. Rehabilitation solves problem (structural, I/I) today and for many years to come
2. Minimum disruption to service (sewer, roadway)
3. No injury to construction crew
4. Completed on schedule and on budget

Keys to a Successful Manhole Rehabilitation Project

1. Understanding normal conditions in manhole and matching to rehabilitation methods
2. Performing rehabilitation per manufacturer specifications
3. Testing to verify materials and installation
4. Understanding potential limitation and incorporating into schedule and budget
5. Communication with rehabilitation manufacturers
Preconstruction Considerations

1. Manpower
2. Equipment
3. Traffic Control
4. Bypass pumping
5. Wet weather / high flow

Case Study
City of Menasha, Wisconsin

- An engineering firm requested inspection and suggested repair methods for the I & I issues for their client
- The manhole liner forming system was introduced as the preferred rehab method
• A demonstration manhole was provided to the client at no cost
• A “field trip” to a different city was scheduled to inspect manholes lined in previous years
• References were investigated

• Engineer and the City agreed to use the manhole liner forming system as the preferred specification for the project
• 110 manholes were restored utilizing the manhole liner forming system.
• The contract total was ½ of what remove and replace would have cost
• The City chose to include new frames & covers and chimney seals with this project
• Many of the manholes were between 50 and 80 years old and most were of brick construction

• Explained by the senior Engineer, “It provides a complete seal against I&I, as opposed to pre-cast structures that contain joints every few feet.”
Manhole Liner Forming System

An interior forming system which allows the pouring of ready mixed concrete between the existing structure and internal pour forms. This forming system completely rehabilitates structures and restore structural integrity, without excavation or interruption of sewer services.

Purpose of a Manhole Liner Forming System

- The purpose of the liner forming system is to provide full structural restoration of failing brick, block & concrete manholes and lift station type structures
- The restoration is accomplished by pouring a monolithic concrete liner within the existing structure
- By design, the new structure will have a typical wall thickness of three inches in the barrel section and five inches in the chimney
Accommodations

- Unique brick and block manholes and structures
- Concentric and eccentric cone sections
- Any size structure can be custom restored
- Benches and inverts are rehabilitated
- Chimney size is typically increased (to std. 26" dia.)

Typical issue that are avoided

- Traffic tie ups and detouring
- Bypass pumping and disruption of service to customers & the community
- Disruption of other utilities
- Street restoration cost and years of ongoing problems with poor compaction
- Noise and mess typically associated with open trench construction
Let’s view the process

Pavement is saw cut and removed by hand.
The old casting is removed and discarded or salvaged for reuse.

Chimney demolition is performed using hand tools.
Chimney demolition performed to achieve 32”-36” inside diameter

Demolition debris is contained and removed for disposal
Demolition is complete at 32”-36” dia.

Sonotube is used for the outside pour-form in the chimney section.
Measurements are made from the street surface to set the top-of-pour elevation.

Release agent is applied to the surface of the internal pour forms.
The bottom form is set and the base joint is sealed.

All pipes are stubbed out of the forms to ensure that no concrete enters the existing lines and also to maintain full pipe diameter through the liner wall.
Pipes are stubbed to forms using PVC

Form installation continues to top
Typical 3” annular space between existing structure and pour-form

Forms are secured using bolts and clamps, as well as shoring when necessary
Chimney section forms are eccentric or concentric

Form installation is complete
Pour hat is installed on top form.

Redi-mix is poured onto pour-hat.
Concrete pour is complete

After ample curing, the pour forms are removed
Sonotube is trimmed to finished elevation.

Form removal continues.
High strength mortar is mixed for bench & invert completion

Bench & invert are completed
New or salvaged casting is set

Base material is installed, compacted and ready for pavement
Street patch in concrete performed by crew, or bituminous patch performed by other.

New concrete patch is finished to existing street surface.
Typical rehabilitation example:

Before

After

Before

After
Manhole Rehabilitation
Construction Perspective

John Selvog
Infrastructure Technologies, Inc.
Toll-Free 800-533-4244
www.infratechonline.com
Questions?

ASSET PRESERVATION FOR THE 21ST CENTURY
MANHOLE REHABILITATION
“LOCAL” COLLECTION SYSTEM MANHOLE

Ocean County Utilities Authority

Established in 1970

Serves a Population \(\approx 600,000\)

All of Ocean County & Southern Monmouth County

3 Wastewater Treatment Plants

40 Pump Stations

160 mi. of Force Main and Gravity Lines

\(\approx 2,100\) Manholes/Greater than 30,000 S.F. Rehabilitated Since 2001
Northern Service Area

- 8 Pump/Lift Stations
- 50 Miles of Interceptor
- 681 Manholes

Central Service Area

- 19 Pump/Lift Stations
- 60 Miles of Interceptor
- 954 Manholes
Southern Service Area

• 13 Pump/Lift Stations
• 40 Miles of Interceptor
• 466 Manholes

ATLANTIC OCEAN  
BARNEGAT BAY
Inspection Sequencing & Scheduling

Inspection using CCTV Performed by Authority

- Including Manholes

Force Main Break to Gravity

- 1,000 Ft. Downstream
- Goal to Inspect Every 3 Years

Remainder of Gravity System

- Goal to Inspect Every 7 Years

Rehabilitated Pipes

- Goal to Inspect Every 10 Years

Manhole Investigation Survey

Original Contract Inspector Location
Manhole Investigation Survey

Original Contract Inspector Location Casting

Manhole Type

Invert Elevations

NOT BAD WORTHY OF ATTENTION
TREATMENT PLANT INFLUENT MANHOLE

WORST CASE

PUMP STATION INFLUENT MANHOLE
SEVERE HYDROGEN SULFIDE DETERIORATION
SEVERE DETERIORATION - > 30 YEARS OF SERVICE

Siphon Inlet Chamber

Areas of Particular Concern

Areas In Contact w/Sewer Gases

“Wetted” Areas

Resulting in Chemical Attack –

- Acid Attacks
- Alkaline & Alkali-Aggregate Reactivity Reactions
- Chloride-Induced Corrosion

Fundamentals of Cleaning and Coating Concrete, Chapter 3 Common Mechanisms of Deterioration, Attack by Atmospheric Gases, Randy Nixon – Chief Technical Editor SSPC 2001
**Appropriate Field Evaluation**

- pH < 4 Allows Concrete to Degrade Readily
- Once Cement Paste is Gone/Moisture Attack Readily Occurs

**Corrections for Manhole Deterioration**

Proper Evaluation Early in Project Evolution

- Utilization of Manhole Investigation Surveys
  - Field Evaluation – Consider Impact of Shut Downs
  - Provide for Corrosion Engineering Involvement
  - Selection of Appropriate Products
  - Applicable Specification Preparation
  - Simple Drawing Presentation
  - Constructability Review

- Results in Minimizing Changes During Construction
Specification Preparation

Surface Preparation

• Water Blasting < 10,000 psi
• Supplement with Abrasive

Restore Cover Over Rebar to Original

• Provide Additional Reinforcement, Where Required

Underlayment/Resurfacer

• Either Fast Setting High Early Strength Portland Cement Based or Silica Fume Cement Mortar
• Surface Restoration/Filling of “Bug Holes”
• Providing Appropriate Surface to Apply Aggregate-Filled Epoxy Lining Material

Grouting and Sealing to Stop Infiltration

Application of “Thick Film” Lining/Coating

• Protective Coating System 60 mils
  Aggregate-filled Epoxy Material

• Chemical Resistance – Acids

• Moisture Vapor Barrier
  Provides for a Permeability – perm-inch per ASTM E96

• Abrasion Resistance

• Trowel Applied or Spray Applied
Bid Phase

Provide for Known Depth of Repair to be Included
In Unit Pricing

Require Strict Manufacturer Involvement in Project

Contractors Bidding Work/ Manufacturers Providing Pricing
Become Familiar w/Specification, Products and Expectations

“Economies-of-Scale” Are being Realized in Competitive Pricing

Underlayment
Underlayment

Protective Coating System

Elastomeric or Coal Tar Epoxy
Quality Assurance

• Pipeline Relining Performed First

• Coating System Manufacturer (CSM) Involvement

• Owner/Contractor/CSM Inspection of Manholes Prior to Start of Work

• Inspections
  – Surface Prep
  – Underlayment Installation
  – Grouting and Epoxy Application

• Ensure compatibility and bond,
  – Concrete repair and protective coating products that will be in contact with each other shall be from the same manufacturer

• If products from different manufacturers
  – Contractor shall obtain from the manufacturers Certificates of Compatibility; that each product is compatible with the other
UNDERLAYMENT RESURFACER

APPLICATION OF UNDERLAYMENT RESURFACER
Sequence

• Installation of new lining shall be performed prior to manhole rehabilitation.

• After relining of the pipe has been completed and surface preparation performed, the manhole shall be inspected for infiltration.

• Manhole coating installation shall be performed after completion of stopping at infiltration.
Grouting Demonstration

Grouting for Infiltration
INSTALLING NEW PVC LINER

FILLING SPACE BETWEEN MH WALL AND NEW PVC LINER
COMPLETED PERMAFORM MANHOLE

CURED-IN-PLACE LINER
Use of Polymer Concretes

Job Well Done
Summary

- Know, Inspect & Document Your Assets
- Perform Condition Assessment & Document Conditions
- Provide Corrosion Engineering Involvement if Required
- Provide Product Manufacturer Involvement
- Prepare Plans & Specifications Clearly Describe Intent
- Perform Quality Assurance During Construction
  - Require Product Manufacturer Involvement
  - Owner/Contractor/Manufacturer Inspect Manholes Prior to Rehabilitation
  - Owner/Contractor/Manufacturer Inspect & “Sign-Off” at the Conclusion of Each Step of the Process
- Perform All Steps SAFELY, Utilizing Sound Principles and Confined Space Entry Procedures

Questions & Answers
Questions?

Q & A Session
**Summary**

- Performing a comprehensive condition assessment using standardized grading is critical to identifying the correct product for each situation.
- Preparation is the critical component to any successful manhole rehabilitation project.
- Employing pre and post-construction QA/QC standards is a key to rehabilitation longevity.
- Confined space entry is required on most every technology. Compliance with OSHA and local regulations are a requirement for any work within manholes.
- Safety includes being aware of surroundings, including traffic control.

**Reference Standards**

- ASTM International
  - ASTM F2551 - 09 Standard Practice for Installing a Protective Cementitious Liner System in Sanitary Sewer Manholes [www.astm.org/Standards/F2551.htm](http://www.astm.org/Standards/F2551.htm)

- American Society of Civil Engineers (ASCE)

- Manhole Assessment & Certification Program
  - [www.nassco.org](http://www.nassco.org)
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Perspectives on Collection System Rehabilitation & Replacement

(Based upon MOP FD-6)

Owner
Contractor
Designer
Manufacturer