Force Main Rehabilitation

An Online Continuing Education Course for Engineers

Course Number: EN-8004

Credit: 8 Hours / 8 PDH / 8 CPD

Force Main Rehabilitation

DEFINITIONS

Cured-in-place pipe (CIPP) – a hollow cylinder consisting of a polyester and/or glass reinforced plastic fabric tube with cured thermosetting resin. The CIPP is formed within an existing pipe and takes the shape of the pipe.

Folded pipe – pipe that has been manufactured and calibrated round, then subsequently cooled and deformed into a folded shape for insertion into the existing pipe.

Force main – a pipe that transports raw sewerage and operates under pressure.

Formed pipe – a folded pipe that has been inserted into an existing pipe and expanded with steam heat and pressure, and, if required by the manufacturer, with a squeegee device or "pig" to provide a close fit to the existing pipe.

Hydrostatic design basis (HDB) – a long-term hoop tensile stress when applied to the pipe or liner continuously for the specified time period (usually 100,000 or 438,000 hours) will result in failure of the pipe or liner.

Partially deteriorated pipe – the existing pipe can support the soil and surcharge loads throughout the design life of the rehabilitated pipe and the soil adjacent to the existing pipe must provide adequate side support.

Fully deteriorated pipe – the existing pipe is not structurally sound and cannot support soil and live loads or is expected to reach this condition over the design life of the rehabilitated pipe. This condition is evident when sections of the existing pipe are missing, the existing pipe has lost its original shape, or the existing pipe has corroded due to the effects of the fluid, atmosphere, or soil.

Non-structural – provides no load-bearing capacity to the pipe; primarily acts as a corrosion barrier.

Open cut – the use of excavation to install a new pipe or replace an existing one.
Rehabilitation – internal coatings, sealants, and linings used to extend operational life and restore much or all of the pipe's hydraulic and structural functionality.

Renewal – improving the structural performance, flow capacity, corrosion resistance or water quality of a deteriorated pipe by repair, rehabilitation, or replacement

Repair – used when the existing pipe is structurally sound, provides acceptable flow capacity, and can serve as the support or host of the repair method.

Replacement – an existing pipe is usually replaced when it is severely deteriorated, collapsed, or increased flow capacity is needed.

Semi-structural – a liner whose long term internal burst strength is less than the maximum allowable operating pressure of the pipeline to be rehabilitated. Semi-structural liners are capable of bridging holes and gaps in the host pipe.

Sliplining – the installation of a smaller diameter replacement pipe inside an existing pipe leaving an annular gap between the two. The replacement pipe can be continuous or made up of discrete segment lengths.

Structural – a liner whose long-term internal burst strength equals or exceeds the maximum allowable operating pressure of the pipeline to be rehabilitated.

Trenchless – the installation of a new pipe or liner with minimal or no excavation required.

UNIT CONVERSION FACTORS

1 meter = 3.2808 feet
1 km = 0.62 mile
1 millimeter = 0.03937 inch
$^{o}F = 1.8(^{o}C) + 32$
MPa = 145 psi
1 bar = 14.503 psi
Psig = psi +14.7 mm = 39.37 mil
1 mile = 1.609 km
1 US$ = 0.748 Euro

ACRONYMS AND ABBREVIATION

3-D three-dimensional

AASHTO American Association of State Highway and Transportation Officials
ACP asbestos cement pipe
AREA American Railway Engineering Association
ASCE American Society of Civil Engineers
ASTM American Society of Testing and Materials
AWWA American Water Works Association
AWWARF American Water Works Association Research Foundation (Now known as the Water Research Foundation)

BEM broadband electromagnetic

CCP	concrete cylinder pipe
CCTV	close circuit television
CI	cast iron
CIPP	cured-in-place pipe
DI	ductile iron
DIPS	ductile iron pipe size
DOT	Department of Transportation
DR	diameter ratio
DSAW	double submerged arc welded
DWI	Drinking Water Inspectorate
EPA	U.S. Environmental Protection Agency
EPB	earth pressure balance
EPDM	ethylene propylene diene M-class
ESCR	environmental stress crack resistance
FRP	fiberglass reinforced pipe
GBR	Geotechnical Baseline Report
GDSR	Geotechnical Design Summary Report
GRP	glass reinforced plastic
GTI	Gas Technology Institute
H_2S	hydrogen sulfide
HCl	hydrochloric acid
HDB	hydrostatic design basis
HDD	horizontal directional drilling
HDPE	high density polyethylene
HDS	hydrostatic design stress
HPL	high pressure liner
H_2SO_4	sulfuric acid
ID	inner diameter
IJS	intermediate jacking stations
IPLT	International Pipe Lining Technologies
IPS	iron pipe size
ISO	International Organization for Standardization
kN	kilo Newton
LPR	linear polarization resistance
MDPE	medium density polyethylene
MFL	magnetic flux leakage
MOP	manual of practice

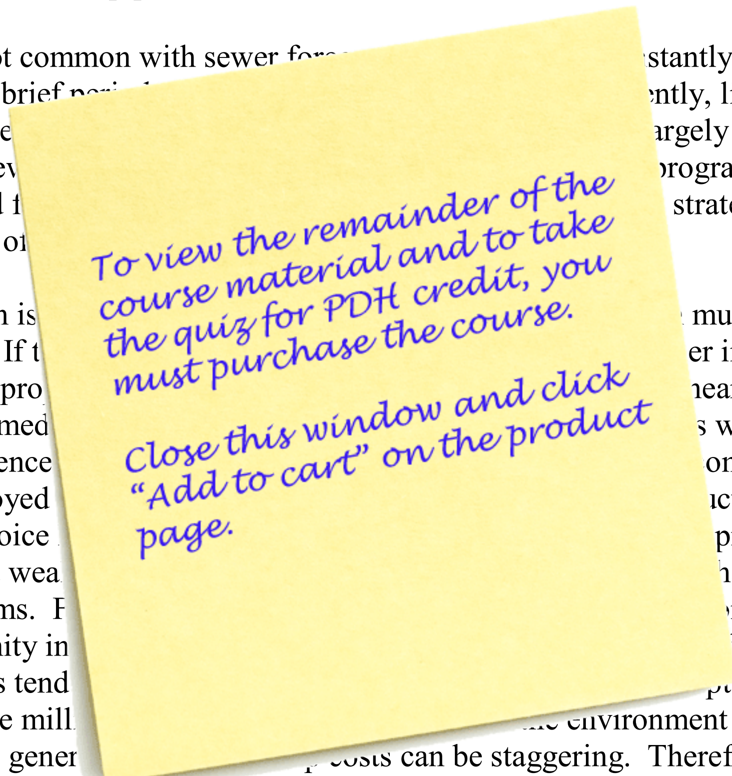
NASSCO	National Association of Sewer Service Companies
NRC	National Research Council, Canada
NRMRL	National Risk Management Research Laboratory
NSF	National Sanitation Foundation
O&M	operation and maintenance
OD	outer diameter
OFWAT	Office of Water Service
PCCP	prestressed concrete cylinder pipe
PE	polyethylene
PIPP	pulled-in place pipe
PPI	Plastic Pipe Institute
PPIC	Pressure Pipe Inspection Company
PPL	pressure pipe liner
psi	pounds per square inch
PU	polyurethane
PVC	polyvinyl chloride
PVCO	molecularly-oriented polyvinyl chloride
QA	quality assurance
QC	quality control
RBI	Risk-Based Investigation
RCP	reinforced concrete pipe
RPL	reinforce pressure line
RPP	reinforced pressure pipe
SDR	standard dimension ratio
SIPP	spray-in place pipe
SOT	state-of-the-technology
TBM	tunnel boring machine
TIM	Tenbusch Insertion Method
TO	task order
TTC	Trenchless Technology Center
UL	Underwriters Laboratory
UV	ultraviolet
WERF	Water Environment Research Foundation
WRC	Water Research Center, UK

1.0 INTRODUCTION

Force mains that carry sewage flows under pressure represent a special set of challenges for sewer rehabilitation. Force mains represent about 7.5% of the wastewater system and they typically use materials that are not commonly used in gravity sewer systems. Ductile iron (DI), cast iron (CI), steel, and concrete pressure pipe are all material types frequently used for sewer force mains, especially in larger diameters. All of these materials are susceptible to both internal corrosion from the sewer flow (liquid and gaseous states), as well as external corrosion due to the environment in which the pipe is buried.

Redundancy is not common with sewer for… …stantly and can only be taken out of service for brief … …ntly, little internal inspection of force … …argely unknown. It has only been in the past fe… …programs for inspecting their underground … strategy. Many of these are a direct result o…

Once a force main is … must be made on the next appropriate step. If t… …er inspection in 10 to 15 years might be appro… …near failing should be candidates for immed… …s with significant negative consequence… …ommon renewal technology employed … …uction. Part of the reason for that choice … …priate for sewer force mains. There is a wea… …has been limited for pressurized systems. F… …rs recognize the growing opportunity in… …for replacement is that sewer force mains tend … …ture of a sewer force main could release mill… …e environment posing significant health risks to the gener… …costs can be staggering. Therefore, the tendency when it comes to considering renewal of a force main is to err on the conservative side and go with outright replacement.



As some of the newer rehabilitation technologies develop a positive track record of use in sewer force mains and confidence in their design approach and installation process strengthens, more utilities will be willing to consider these trenchless technologies as potential renewal solutions. This is especially true if the rehabilitation technology is significantly cheaper than replacement with open cut construction. The gap between funds needed to restore the integrity of the underground infrastructure to an acceptable level of reliability and available funds is widening. One way to close the gap is to find more cost-effective methods of rehabilitation than open cut replacement. Trenchless methods have proven themselves to be cost-effective for gravity sewer mains, especially when both direct and indirect costs associated with a replacement program are