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Abstract **-** Trenchless technology has become common around the world where no excavation takes place. This study reveals the new innovation in the trenchless rehabilitation-Cured In Place Pipe (CIPP). CIPP mainly deals with the rehabilitation of subsurface pipes where a pipe within a pipe is inserted. This method prevents traffic disruption, damaging of roads whereas in digging process the public life is very much disturbed.CIPP stands superior when compared to other trenchless methods. Using CIPP the pipeline system has developed a lot and many companies have started adopting this system in a large scale.

Keywords- *CIPP, Installation, CIPP Technology, Applications, Merits and demerits.*

1. INTRODUCTION

CIPP (Cured in place pipe) developed in 1971 is a trenchless technology rehabilitation method. Simply explained, CIPP is resin saturated polyester felt tube (with an exterior coating) inverted or pulled into an existing pipe or host pipe, inflated then heat processed (with steam or hot water) to cure and harden the resin. The result is a new pipe constructed within a pipe that is one piece and both seamless & joint less. Little to no digging is involved in this trenchless process, making for a more environmentally friendly method than traditional "dig and replace" pipe repair methods. CIPP installation can normally be completed in less than 18 hours with minimal surface disruption or other inconvenience. Service laterals (internal pipe connections) are restored internally with robotically controlled cutting devices operated and monitored by CCTV from aboveground.

2. INSTALLATION

The CIPP is a quick process for installation. The installation process of CIPP is shown in Fig.1 which consists of three process:

2.1.Cleaning and Inspection: Prior to lining the existing sewer, it is cleaned using high pressure water hoses and video cameras to inspect the cleaning and record the condition of the sewer pipe.

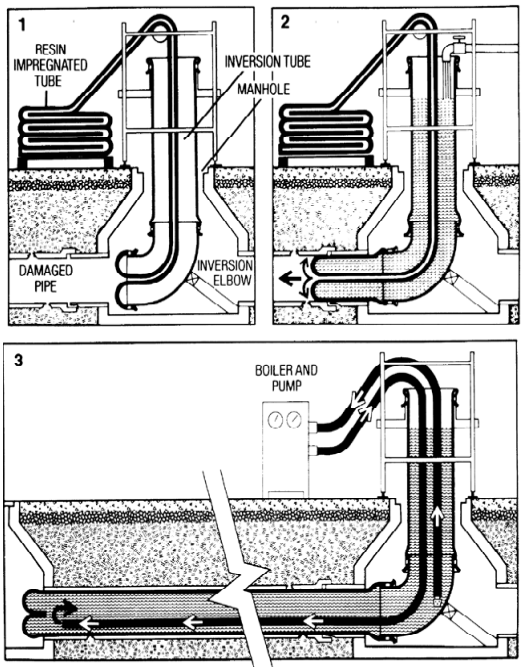


Fig 1. Installation of CIPP

Table 2.1 Materials used & Applications of CIPP

Liner Tube Material	CureType	Resin	Main Application
Polyster Felt	Heat or amibent	Pe*,Ve,Ep	Gravity Pipes
Glass			Pressure

Reinfor-ced Polyster Felt	Heat	Ve**,Ep	Pipes
Glass Fibre Structural Fabric	Heat	Pe,Ve,Ep	Gravity and Pressure
	Light	Special	Gravity
Circular Woven Polyster Fibre Hose	Heat or Ambient	Ep***	Pressure
Woven Hose Plus Felt	Heat	Ep	Pressure
Woven Hose Plus Felt Plus Structured Glass Fibre Fabric	Heat	Ep	Pressure

2.2. Pipe Lining: The process starts with placing a flexible liner into the existing sewer. Steam or heated water is forced into the liner, pushing the liner tightly against the existing sewer walls. The heat causes the liner material to cure creating a new pipe within the existing sewer that is free of cracks and holes. During the installation, sewer flows are re-routed using pumps and hoses, to ensure sanitary service to customers.

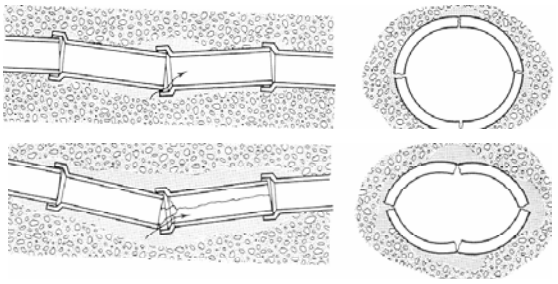
2.3. Reinstating Laterals: Once the liner has been cured, the existing lateral pipes serving each home need to be cut open. This process is completed using a remote operated cutter and video camera..Usually the installation process is completed in a few hours whereas digging process requires days for the completion of the process.

3. CIPP TECHNOLOGY

3.1. Causes for failure in sewer pipes

Failure of sewer pipes due to traffic loads is brought about primarily by the cyclic live loads transferred to sewer pipes via manholes on paved road surfaces. The causes of sewer pipe failure include subsidence of the area around a manhole, loosening of sewer pipe joints caused by such subsidence, seepage due to such loosening, cavities caused by seepage induced runoff of sand, and collapse of the ground due to such cavities. In addition, earthquakes with vertical and horizontal vibrations lead to different failure modes of sewer pipes. It is therefore important to investigate the failure properties of sewer pipes in relation to waveforms of cyclic live loads.The pipe failure is shown in fig.2.The potential causes are:

- explosions or severe corrosion caused by discharge of uncontrolled industrial wastes,
- odors,



- corrosion of sewer lines and manholes caused by generation of hydrogen sulfide gas,
- collapse of the sewer line because of overburden or corrosion,
- poor construction, workmanship or earth shifts causing pipes to break, joints to separate, and manhole walls to crack, resulting in excessive infiltration/exfiltration,
- protruding taps in the sewer lines caused by improper workmanship (known as plumber taps or hammer taps) that can substantially reduce line capacity and contribute to frequent blockages,
- excessive settling of solids in the manholes and lines, which can lead to obstruction, blockage or generation of undesired gases,
- reduction of the diameter of the sewer line by accumulation of slime, grease, and viscous materials on the pipe walls, leading to blockage of the line, and
- faulty, loose or improperly fitting manhole covers leading to inflow.

3.2.Cured–in–Place Pipe Technology

The CIPP product itself consists of a soft, flexible felt or felt composite tube that is impregnated with a thermoset resin. Cured-in-place pipe (CIPP) technology allows for the renewal of damaged underground wastewater and storm sewer pipe without excavation. In the past, damaged pipes were excavated and replaced. With CIPP technology, a felt sleeve – saturated with resin and coated with a waterproof layer – is inserted into the pipe. Hot water (or air) is then circulated through the sleeve, which cures the resin. This material now serves as a barrier between the damaged pipe and the water that flows through it; or as a new stand–alone pipe of its own.

3.3.Betterment of CIPP than pipe replacement

CIPP is a no–dig technology, which means that the pipe can be salvaged without the hassles of rerouting traffic and closing streets. This is especially beneficial in urban and downtown areas where altering traffic patterns can

cause lengthy delays. By eliminating the excavation phase, projects can also be completed up to five times faster, and at 40 to 50 percent less cost.

3.4. Inliner's technology-The superior to other CIPP treatments

Inliner Technologies has two patented features that offer customers a superior result: ResinGuard and StretchGuard. ResinGuard is a patented impermeable membrane that protects the felt from resin washout, drag–off, squeeze-out and contamination, and yet still allows the resin system to form a mechanical lock with the host pipe. When the inner–felt is protected with this membrane, the pipe maintains a more uniform thickness, which can actually result in an increase in the structural capacity of the pipe because of less loss from migration and co–mingling during processing (or manufacturing).

StretchGuard tubes minimize the stretching that occurs when a liner is pulled or inverted, assuring even further a uniform, maintained thickness – which ultimately assures adherence to the design's finished parameters. The Inliner Technologies method can be used to renew a whole range of pipes including sewer, raw water, cooling water, and process effluent systems in diameters from 4 to 120 inches.

3.5.Usage of Inliner Technologies products

The CIPP method of pipe renewal is a viable option for communities everywhere, and it is on the approved list of products in hundreds of municipalities and sewer districts throughout the country. Many large manufacturing–based corporations also view the CIPP method as a preferred method of rehabilitation of their damaged and/or corroded pipes. It is applicable for round, elliptical, rectangular, and egg–shaped cross-sections. Inliner products are designed to withstand continuous service in corrosive environments for up to 50 years (or longer).

TABLE 3.1 CIPP TECHNICAL ENVELOPE

CIPP TECHNICAL ENVELOPE	
Diameter Range	6 to 96 inches
pH Range	.5 to 10.5
Effluent Temperature	Upto 140
Fully Deterioated Pipe Condition	Yes
Patially Deterioated Pipe Condition	Yes
Offset Joints	Yes
Diameter Changes	Yes,without manhole access
Thickness changes	Yes,without manhole access
Host Pipe Shape	All Shapes
Host Pipe Material	All Material
Bends	Yes
Typical Short Length	200ft. To 1000ft.s

4. CIPP AROUND THE WORLD

Cured-in-place pipe or CIPP is a popular pipe rehabilitation method around the world.CIPP creates a close-fit 'pipe-within-a-pipe' that has quantifiable structural strength and can be designed to suit various loading conditions.

The installation process varies from country to country as the pipe system differs in every region.

4.1.CIPP making tracks in Wiltshire

A sewer dating back to the 1960s that runs alongside the Bristol to London railway line in the UK was recently repaired using CIPP. The ageing Asbestos Concrete (AC) sewer, operated by Wessex Water, had suffered a number of fractures and was relined using CIPP to safeguard it for the future.

A CCTV (Closed - Cicuit Television) investigation of the 650 m long sewer revealed that it had lost structural strength and sections exposed to the elements had caused exfoliation of the outside surface leading to a number of ring fractures – a common problem for AC sewers.

Once the cleaning was complete, the sewer was relined in two shots using liners measuring 325 m and 323 m.

4.2. CIPP in Singapore

In 2009, Public Utility Board (PUB), Singapore's publicly-owned water utility, began work on a multi-year $US295 million rehabilitation program. This rehabilitation program is expected to be completed in 2014 and will upgrade over 700 miles of public sewers and 30 miles of pumping mains. PUB serves a population of over 4.5 million Singaporeans. These contracts are part of PUB's ongoing rehabilitation program.

Relining company Insituform Technologies Singapore subsidiary, Insitu Envirotech, has been awarded four contracts totalling $US18.5 million. Under the contracts, Insituform will perform work for the PUB, and rehabilitate approximately 50 miles of sewer pipeline though the use of the CIPP process.

4.3. A record-breaking installation in Helsinki

The Olympic Stadium in Helsinki, Finland, the location of the 1952 Summer Olympics, is undergoing a major renovation. One challenge was the vertical rainwater pipes in the 72 m Olympic Tower. Making changes to the structure of the tower is prohibited, and

contractors were not allowed to excavate, so no new pipes could be installed. As well as the rainwater pipes, the outlets and connections were also in very bad shape.

After careful planning and calculation, a conclusion was made that CIPP Lining could be installed in one 72 m stretch. The pipelines were cleaned, the side connections were installed, and the liners went up to the top of the tower as planned. Including all the preparation works, the job took only four days.

4.4. CIPP doesn't stop traffic in Australia

In Perth, Australia pipeline rehabilitation specialists Drilline Pty Ltd recently completed the CIPP relining of over 650 m of oviform sewer pipes through Perth's city centre.

The project, commissioned by the Water Corporation, called for the rehabilitation of the gravity-fed sewer system along St Georges Terrace, the only road that bisects the city centre east to west without interruption.

The challenge was to complete the works with minimal disruption to the flow of traffic, while maintaining the integrity of the reline. The works program called for the CIPP relining of 650 m of gravity-fed sewers to be broken into seven portions, each portion including jet washing, pre-and post-reline CCTV surveys, reinstatement of junctions and refurbishment of the access chambers.

The project was further complicated by the need to access, monitor and King Vac (vacuum recovery) the private pumping stations servicing each of the office buildings along St Georges Terrace during the bypass periods, including Perth's largest building Central Park. Drilline liaised with building management for each of the buildings prior to the commencement of the project and in the lead up to each new section. Working at night and weekends did reduce the flow, resulting in reduced risk to Drilline personnel and other stakeholders in the bypass component of the project.Drilline successfully completed the St Georges Terrace Sewer Rehabilitation Project in a highly visible location, to exacting deadlines, within extreme time constraints and additional complex third party liaison without compromising the integrity of the oviform CIPP relining works or the safety of its personnel.

4.5.Drinking to relined pipelines in British Columbia

Increased demand for sewer and water pipeline rehabilitation in British Columbia, Canada, initiates a significant sewer relining contract.

Drinking water pipelines in Victoria, British Columbia are set to be relined in a project incorporating CIPP solutions. Over 11,000 feet of pipelines with 12 inch and 20 inch diameters will be fitted with HDPE liner in the project, which is aimed at causing minimal disruption to communities.

A $US4 million contract for the project has been awarded to Insituform, who has recently opened a new office in Montreal, Quebec. The project is expected to be completed in early 2011.

4.6. CIPP under the Baltic Sea

Water from the Baltic Sea was leaking into the broken sewerage networks of the city of Norrköping, Sweden – with expensive sewer pumps working 24 hours a day. CIPP came to the rescue. Norrköping Vatten (NOVA) is a company owned by the municipality of Norrköping. The company is responsible for all water supplies and for the operation of more than 180,000 kilometres of buried pipes. Part of the pipe system runs under the old harbour of Norrköping, in the Bråviken inlet.

The 945 metres of broken pipe, in various diameters, was relined in less than a week. . The leaks amounted to 300 million litres of water every year, equivalent to a cost of ($US121,670) per year in electricity. The high volumes were occurring approximately 100 days of the year. The cost in order to purify this quantity of water, was ($US40,578) per year, which in total adds up to an annual saving of ($US 162,258). harbour of Bråviken was nominated and awarded the best Scandinavian No-Dig project for 2009.

4.7.Plans with CIPP in INDIA

Subhash Projects & Marketing Ltd, in joint venture with US-based Insituform, has bagged an order worth Rs 138 crore from Delhi Jal Board for the refurbishment of the trunk sewerage system in West Delhi. The order entails the refurbishment of two trunk sewer lines—West Delhi (7.04 km) and Jail Road (6.79 km)—using CIPP structural lining method.

US-based Insituform Technologies Inc. would have an exclusive tie-up with Subhash Projects & Marketing to bring its innovative cured in place pipeline (CIPP) technology to India. The novel technology is a joint-free, seamless, pipeline-within-pipe with the capacity to rehabilitate pipes ranging from 6" to 96" and to negotiate bends. This technology renovates old pipelines without having to replace them or cause any disturbance to surroundings.

5. MERITS & DEMERITS

5.1. Merits

- CIPP eliminates infiltration and exfiltration
- It restores structural integrity

- It prevents sinkholes and surface settlement
- It eliminates joints & leaks
- It increases flow capacity
- It protect pipes from corrosion
- It increases pipe strength
- It reduces maintenance
- Minimal traffic disruption in CIPP
- Fewer social costs to open-cut
- Suitable for irregularly shaped pipes and changes in pipe diameter
- CIPP allows for pipes to be rehabilitated in place of traditional replacement that requires excavation and disturbs the surrounding neighborhoods and businesses.
- CIPP is less expensive than replacing the pipe.
- CIPP allows for an increased sewer flow capacity.
- CIPP has a 50-year design life.
- CIPP is completed in 1-3 days versus 6-9 months for traditional pipe replacement construction.

5.2. Demerits

Even though CIPP provides a lot of benefits, but still some disadvantage persists.

- In gravity pipes, where flows are very low, it may be possible to plug any incoming pipes and to rely on the storage within the system.
- In other cases flow diversion or over-pumping will generally be required.
- Tightness of liner to pipe is questionable; an annular space exists.
- Since standard size of CIPP only is available that is suitable for the host pipe, new pipes should be manufactured when the host pipe is of a new size.
- It is also quite expensive for installation.

6. CONCLUSION

CIPP has emerged as a great solution for the rehabilitation of pipe lines around the world due to its credits for Minimal traffic disruption, protection of pipes from corrosion, less maintenance and a time saving process. Also it has life period of about 50 years. Since the process is quite expensive it is not adopted on a large scale. But there is no doubt that the future scope lies in the hands of CIPP for the rehabilitation of pipes in the world.

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