Sewer Line Rehabilitation using CFRP Structural Liners

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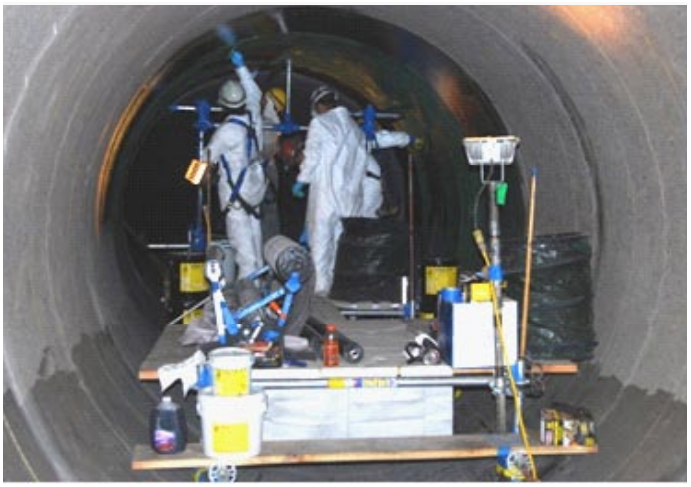
Many of the main sewer lines in service today are reinforced concrete pipes, which as a result of aging and/or lack of proper maintenance have begun to show signs of deterioration and are in urgent need of repair. Given the cost and difficulty of replacing the lines, clearly a strong economic incentive exists to find alternative solutions to rehabilitation.

One such alternative is the use of a Carbon Fiber Reinforced Polymer (CFRP) structural liner, since it represents a "no dig" (trenchless) long term solution to chemical attack, corrosion and leak related problems in pipelines. CFRP liners are saturated with epoxy resins, applied to the surface of the pipe and allowed to cure. Once cured, they become an adhered laminate.

Installation Process

CFRP liners are usually applied directly to the inner surface of the pipe. If designed properly, the liner can replace the material lost due to corrosion, restoring or exceeding the original structural integrity of the line. CFRP liners have inherent resistance to aggressive chemical attack, which makes them suitable for urban as well as industrial sewer line rehabilitation. The chemical resistance of the liner can be further increased by using specially formulated epoxy top coats.



Application of tack coat on upper half of pipe.

Since access of installation crews, equipment and FRP materials is through existing manholes, the need for excavation and fill activities is eliminated. This can reduce the downtime of the sewer line significantly. The structural properties of the liner can be modified by the design engineer to minimize the number of CFRP layers required to meet the project demands, which can further improve installation speed and quality control.

Although there may be variations on the installation procedure of CFRP liners, depending on the manufacturer, the installation process in general follows the following sequence:

1. Prep Work: The pipe surface to be covered by the CFRP must be clean and relatively smooth and thus sandblasting and concrete patching and/or grinding may be required. Also large cracks must be epoxy injected to avoid humidity intrusion. Sealing compounds are usually applied on the bottom half of the pipe to prevent excessive absorption of epoxy saturating resins into the concrete.
2. Installation of CFRP Liner: This can be done using a wet or dry layup. In the dry layup option, the CFRP liner is applied unsaturated over the previously tack coated top half surface of the pipe. The tack coat seals the top portion of the pipe and holds the CFRP in place while epoxy saturation is done using rollers. The bottom half of the pipe is usually not tack coated, since it is sealed during the prep work phase and the CFRP is held in place by the relative tackiness of the epoxy saturating resin and by gravity (the CFRP becomes heavier when saturated). In the wet layup option, the main difference is that CFRP is saturated before applying it to the pipe surface.
3. Installation of Top Coat: This is done if very aggressive chemicals that can damage the epoxy or the CFRP fabric are present in the air or sewage flow.

Equipment lowered through an existing manhole as the lining process begins.

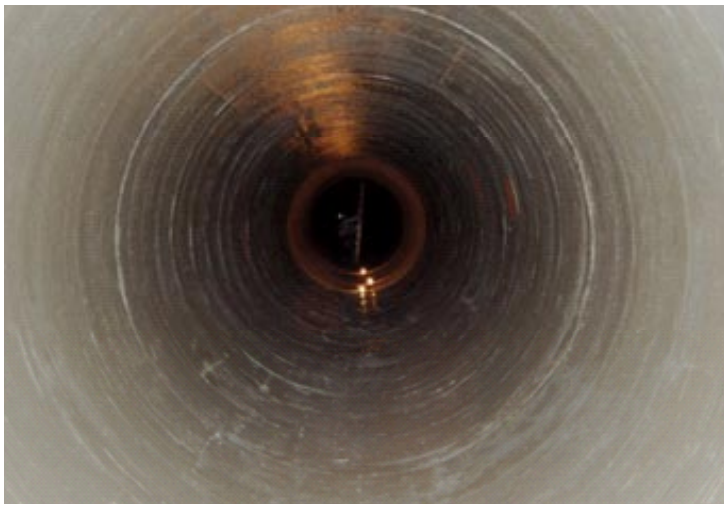
Installation can be achieved with a 3 to 4 man crew and depending on the equipment used (scaffolding design, saturation machines, etc.) and the experience of the crew about 2,500 ft2 of CFRP can be installed in a 24 hour period.

Recently QuakeWrap, Inc. introduced PipeMedic™, a new generation of CFRP liners that consist of coiled, pre-cured laminated sheets. When taken inside the pipe and released, their "elastic memory" makes them extend and conform to the inner pipe surface – like a loaded spring. The laminate can be installed in individual bands or continuously (spiral), regardless of the diameter of the pipe (one size fits all). Epoxy tack coats are used as the adhesive between the laminate and the pipe surface.

Improved quality control and installation speed is achieved with this new system since in situ epoxy saturation of the liner is not required. Also, multiple layered liners can be fabricated with relative ease in manufacturing plants, including liners with galvanic corrosion barriers to avoid direct contact between the CFRP and the surface of steel pipes.

Economic Considerations

The unit prices of most CFRP liners are in the range of $20 to $30 per square feet of installed liner, which is relatively high compared to other structural liners, such as reinforced gunite and steel jackets. However, their competitive edge is in the higher quality control, speed of installation (reduced service downtimes), corrosion mitigation properties, low labor costs, as well as the fact that they can provide a long term, maintenance-free solution. Moreover, the fact that the no excavation is required to access the pipe provides additional savings and allows for the immediate rehabilitation of sewer lines buried under heavily populated areas, main streets, highways or industrial facilities.Since the initial technological applications of carbon fabrics were within the aerospace industry, only a limited number of manufacturers could meet their stringent quality control demand and thus a limited supply drove their prices up. The new demands of the construction and rehabilitation industries are generating the incentive to increase the supply, which would tend to lower their price and further increase their competitiveness.



Final appearance of CFRP retrofitted pipe.

Conclusion

CFRP structural liners provide an alternative for the rehabilitation of buried reinforced concrete sewer lines. Their inherent chemical resistance and impermeability provide a protective barrier against chemical attack on the concrete and an effective corrosion mitigation measure for the steel reinforcement. Their light weight and flexibility allow for small installation crews applying the liner to straight pipe segments or segments with significant geometrical complexity (curves, connection points, etc.). Their thickness is usually around 1/8"after curing, which has a minimal effect on the flow capacity of the sewer line.

Their relatively short installation time minimizes service downtimes and allows for the rehabilitation of large segments of the sewer lines during programmed maintenance service shutdown periods. Recently introduced CFRP pre-cured liners guarantee to reduce the installation time even further. WW

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