TECH TIPS FROM NASSCO

REINFORCED MATERIALS ENHANCE CIPP DESIGN AND PERFORMANCE

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Traditional Cured-In-Place Pipe (CIPP) liners are made using needle punched PET felt materials that are designed to keep the resin in place during the installation and cure process. The finished product is typically around 85% resin and 15% felt with the resin providing the mechanical properties and corrosion performance of the cured composite. Although the flexural modulus of the neat resin is not significantly impacted when combined with the felt liner to produce the composite CIPP, flexural and tensile strength typically realize a reduction of the neat resin properties of 50% or more.

As the CIPP industry has grown, contractors and liner manufactures have developed products that take advantage of fiber reinforced materials to enhance various physical properties in order to meet the needs of particular applications. Unlike the felt material that can have a negative impact on properties, fiber reinforced materials can be used to significantly improve the strength and modulus properties. The final properties and performance of the cured liner will be a function of the volume and type of fiber reinforcement used, the orientation of the fibers, and their location within the composite. The types of reinforcing fibers used include glass, carbon, and in some cases Kevlar®.

Fiber reinforced materials come in a variety of configurations. Fiberglass or carbon tows are continuous length bundles of a large number of individual fibers. Chopped strand mats are made of randomly orientated fiberglass strands held together by a binder which will dissolve in the resin allowing the fibers to then move. Woven rovings are made using bundles of continuous fibers interwoven to form a mat material. These continuous fiber mats can be highly customized adding chopped strand fibers, specifying the amount of fiber in each direction, and placement of fibers on a 45 degree or triaxial orientation. Fiberglass reinforced liners can also be constructed to allow for reliable expansion during installation. This level of customization allows liner manufacturers to tailor the composite to meet the specific needs or end use of a particular application. Newer fiberglass material construction allows for some types of fiberglass substrates to expand when the liner is expanded.

Most UV-cure CIPP liners are made using fiberglass mats that combine continuous fibers along with some level of chopped strand fibers. Fibers oriented in the hoop or circumferential direction offer the most benefit for resistance of external buckling forces particularly on non-pressure pipe applications. There is some level of reinforcement required in the longitudinal direction as well to handle the pull in forces associated with the installation process. Resin to glass ratios of these liners range from 40% to 60% glass creating an extremely strong composite structure. Flexural modulus values of 1.5 to 2.4 million psi or higher and flexural strength values of 25,000 to 50,000 psi and higher are common for these fiber reinforced materials.

Hybrid fiber reinforced felt liners were originally developed to target pressure pipe applications. The controlling design value is tensile strength for CIPP in pressure pipe applications; the fiber reinforcement is used to increase the tensile properties. The earliest iterations used chopped strand mat fiberglass attached or needled into the felt material. Properties of these types of materials are more isotropic and any improvement in flexural modulus may be minimal dependent upon placement of the reinforcing layer within the composite construction. Many of these hybrid liners now take advantage of continuous fiber mats which allow a higher percentage of the reinforcing fiber to be placed in the hoop or triaxial direction. The added customization has allowed for the development of CIPP for pressure pipe applications that have significantly higher tensile strength, increasing the technical envelope to accommodate a wider range of pressure applications.

Fiber reinforced liners are now finding increased usage in standard gravity applications for large diameter pipe rehabilitation. The required wall thickness of gravity CIPP is typically controlled by the flexural modulus of the cured liner, although it may be controlled by flexural strength in structures with flat wall sections like box culverts and some inverted egg shaped pipes. The flexural modulus was initially increased by using resin enhancers or fillers. The addition of fillers to the resin increased the flexural modulus allowing for a reduction in the wall thickness of the CIPP. Construction has evolved to incorporating fiber reinforced layers to increase both the flexural modulus and flexural strength of the composite. The fiber reinforced layers are typically added to the outer and inner layers of the liner with the middle or sandwich layers made with the standard felt. This construction creates an I-beam structure that has significantly higher flexural modulus and flexural strength. These high modulus composites allow for thinner CIPP design which reduces resin consumption saving the customer money with the added benefit of increasing flow capacity. The lower weight also helps with material handling and increases the length of liner that can be transported to the job site. In addition, fiber reinforced liners typically have higher creep retention properties than standard felt products. The higher creep retention can be used to further reduce the design thickness of the installed liner.

While there remains some level of education that is required for the design engineering community on potential opportunities and uses for fiber reinforced composites, these products are now fairly widely accepted. As the demand for gravity and pressure pipe rehabilitation continues to grow, manufacturers and contractors will continue to work together to further advance the use of these high tech, fiber reinforced products throughout the industry.

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