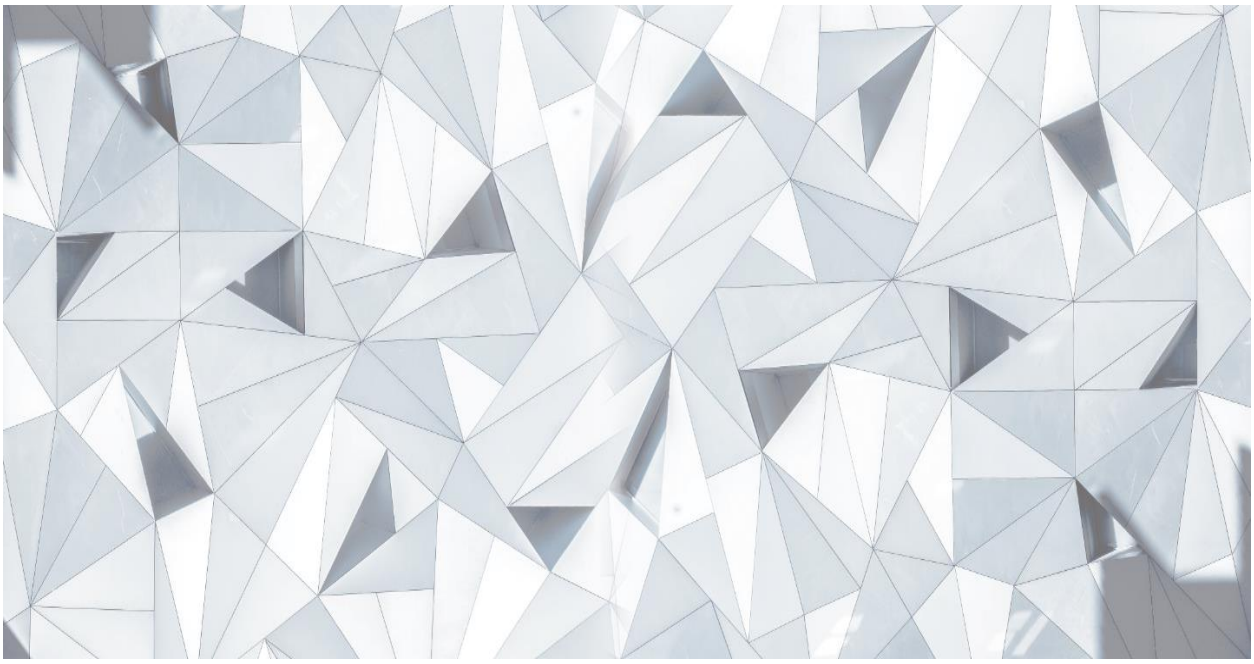
FEBURARY 2024



HYBRID FELT – IMPROVED STRENGTH AND COST-SAVING LINER FOR CIPP INDUSTRY

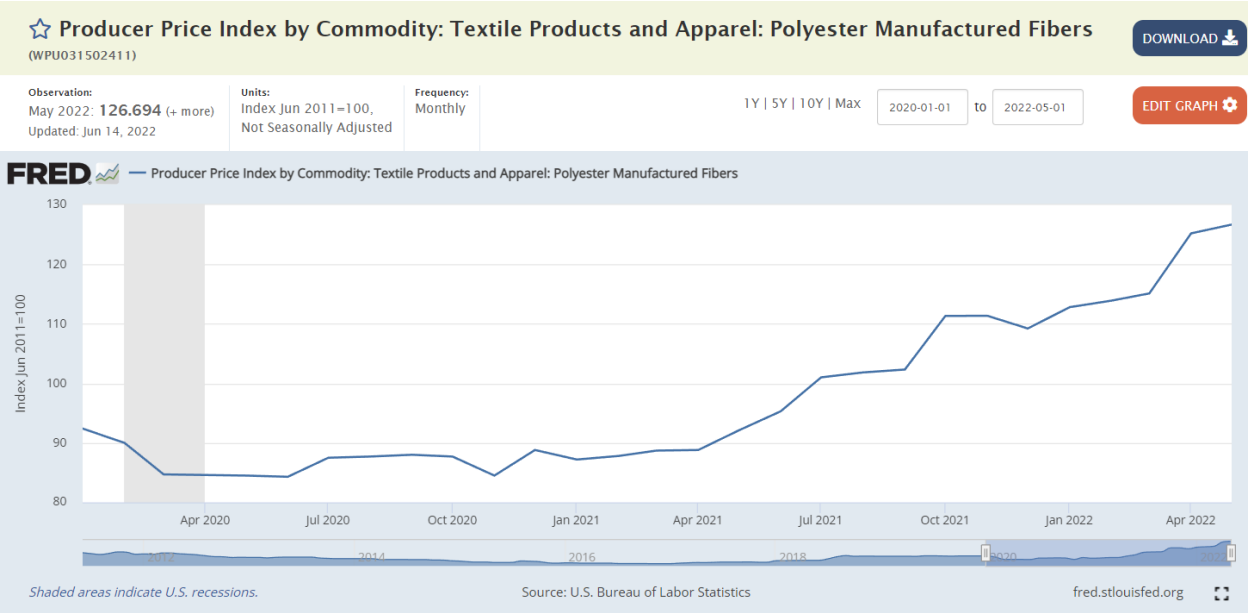
BROUGHT TO YOU BY: INNOVATIONS AMPLIFIED

Innovations Amplified and Tex Tech Industries have development a revolutionary hybrid felt material designed for the Cured In Place Pipe industry. The use of hybrid felt material creates a significant advantage to relining pipes of various sizes. A hybrid felt has the two-fold benefit of reduced thickness while maintaining the required strength. The significant advantage of using a stronger, thinner hybrid felt material is the reduced amount of resin used to wet out the installed liner. This newly developed hybrid felt material has the advantage of lowering the cost of the installed liner by reducing the amount of resin used while maintaining the required strength at about half the thickness and keeping the desired handling characteristics of traditional polyester felts.

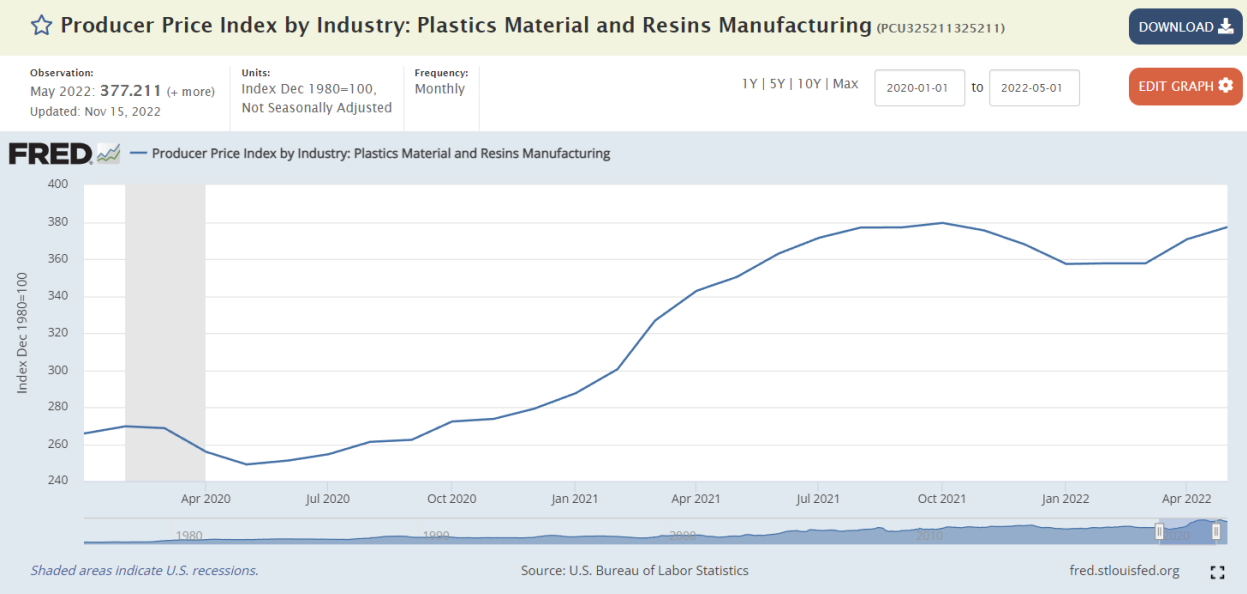
Combating rising costs can be challenging. Choosing a sustainable and repeatable approach without sacrifices determines the longevity of cost savings. Hybrid felt material provides real cost savings with minimal changes to materials and processes.

Raw material trends: Rising Costs are rampant

See the charts below comparing the two constituent raw materials that are the building blocks of CIPP, Polyester fiber & plastic resins.



Polyester pricing realized an increase of ~37% between January 2020 and May 2022



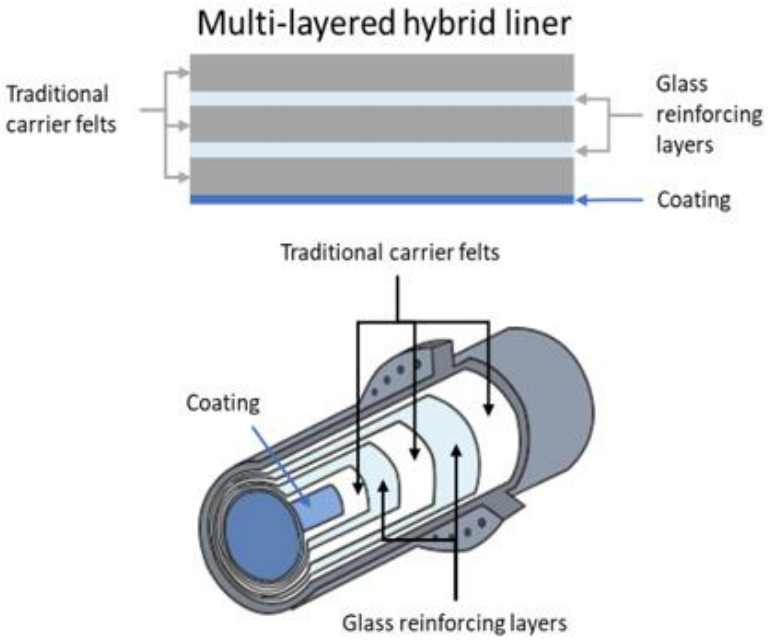
Plastic resin pricing increased ~42% between January 2022 and May 2022

Glass & glass products have increased ~13% between January 2022 to May 2022

Traditional CIPP methods & materials

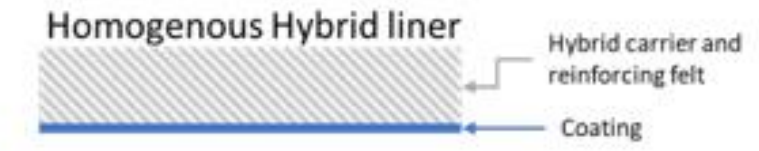
Traditional CIPP felts use 100% polyester as the carrier fiber and adds little to no strength to the liner.

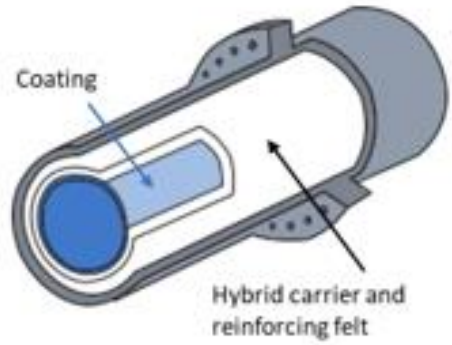
Woven glass or glass mat layers are added to meet strength requirements where appropriate.



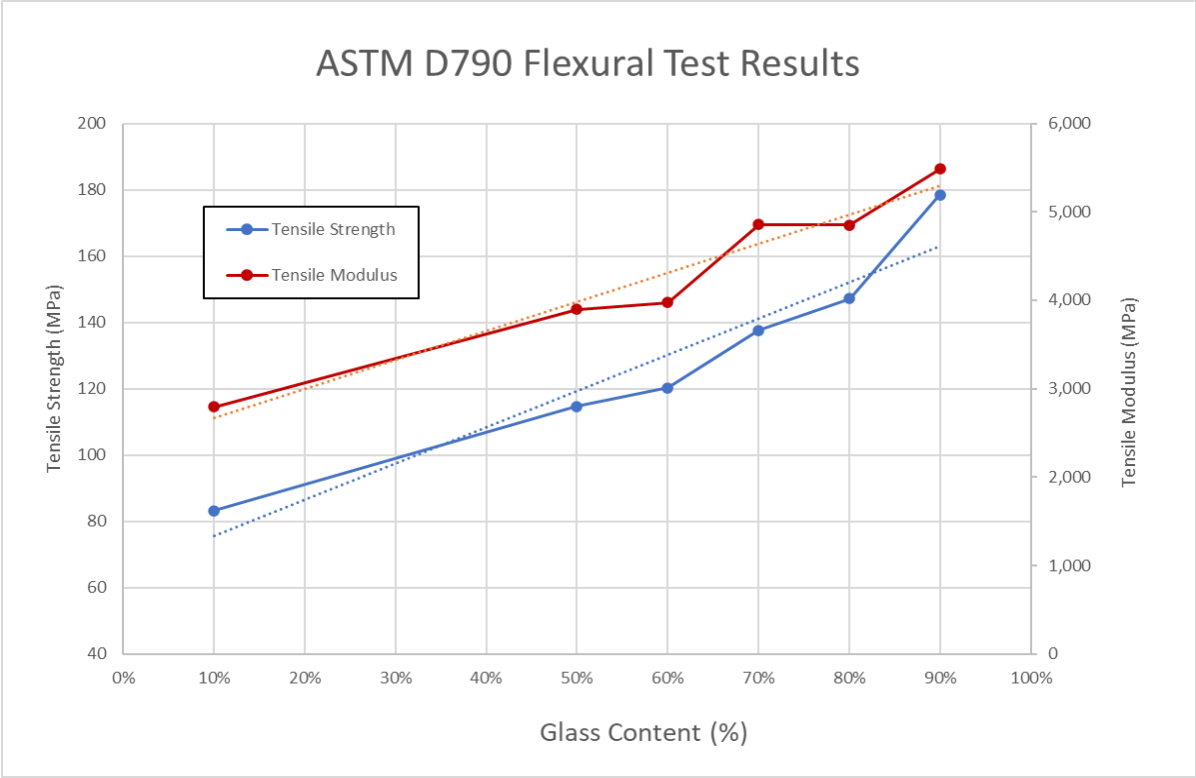
The common reinforcement layer used for relining pipes is glass. Hybrid felt is not limited to glass alone. Other fiber materials can be used to meet strength requirements for unique industrial applications.
Adding reinforcement fibers in layers changes the handling characteristics of the liner, limiting the methods used for wet out and installation.
An alternative option is to blend less-expensive staple glass fiber to the polyester fiber during the needle-punching process creating a hybrid felt material.

Hybrid felts and their benefits
The distinctive qualities of hybrid felt material is accomplished through a manufacturing process using In-line blending. Manufacturing trials were performed using In-line blending of staple polyester & staple glass at various percentages and ASTM D-790 Flexural testing was performed on the cured felt and hybrid laminates.





Initial test of In-line blending was conducted and the results were very positive.

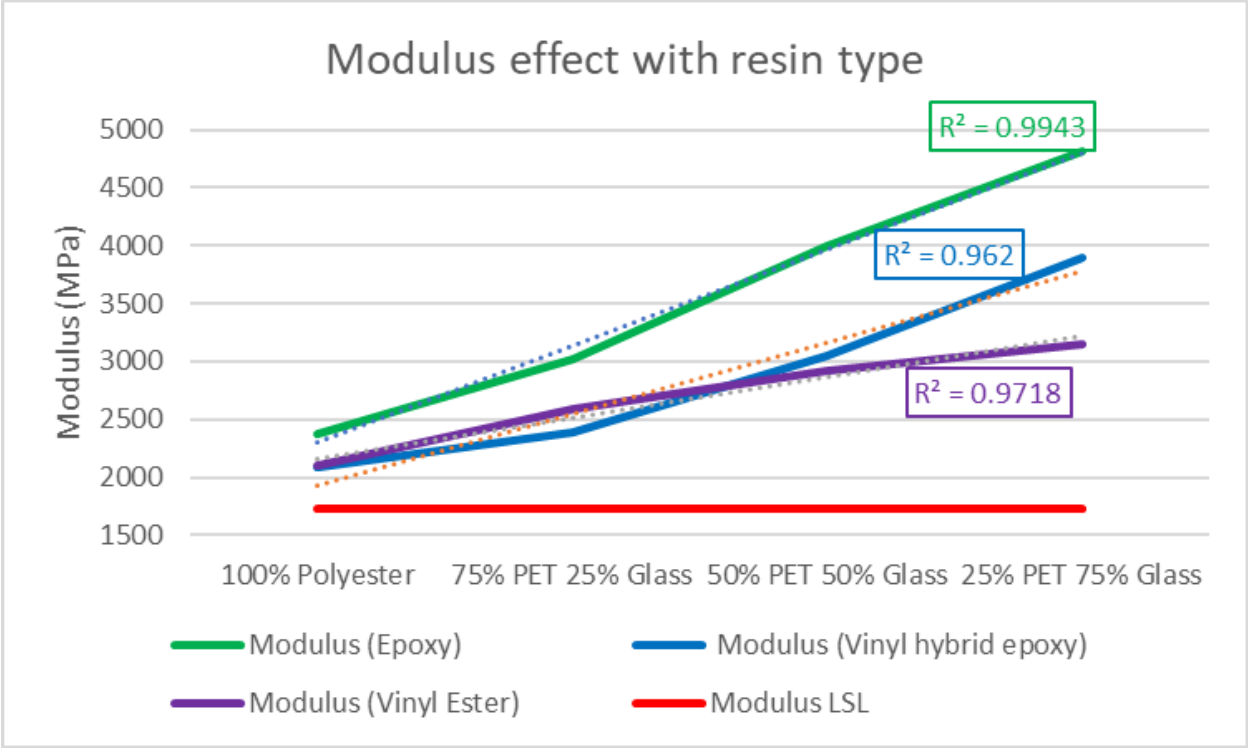


The flexural strength showed ~ a 2X improvement with 50% glass blended and the modulus showed ~60% improvement with 50% glass blended.

Hybrid felts & characterization – Flexural Modulus

There are many factors that can impact the performance for the flexural strength and modulus. The first factor that was investigated was resin type. Resins vary greatly in price and performance. Three commercially available CIPP resins were chosen for these tests: a styrenated vinyl ester, a non-styrenated vinyl hybrid and a 2-part epoxy system. All were cured using the manufacturer's recommended processes.

Felt consisting of 100% Polyester using each of the three resin types has the lowest result. Hybrid felt consisting of 75/25 Poly/Glass, 50/50 Poly/Glass and 25/75 Poly/Glass improved in Flexural Modulus respective to the type of resin used.

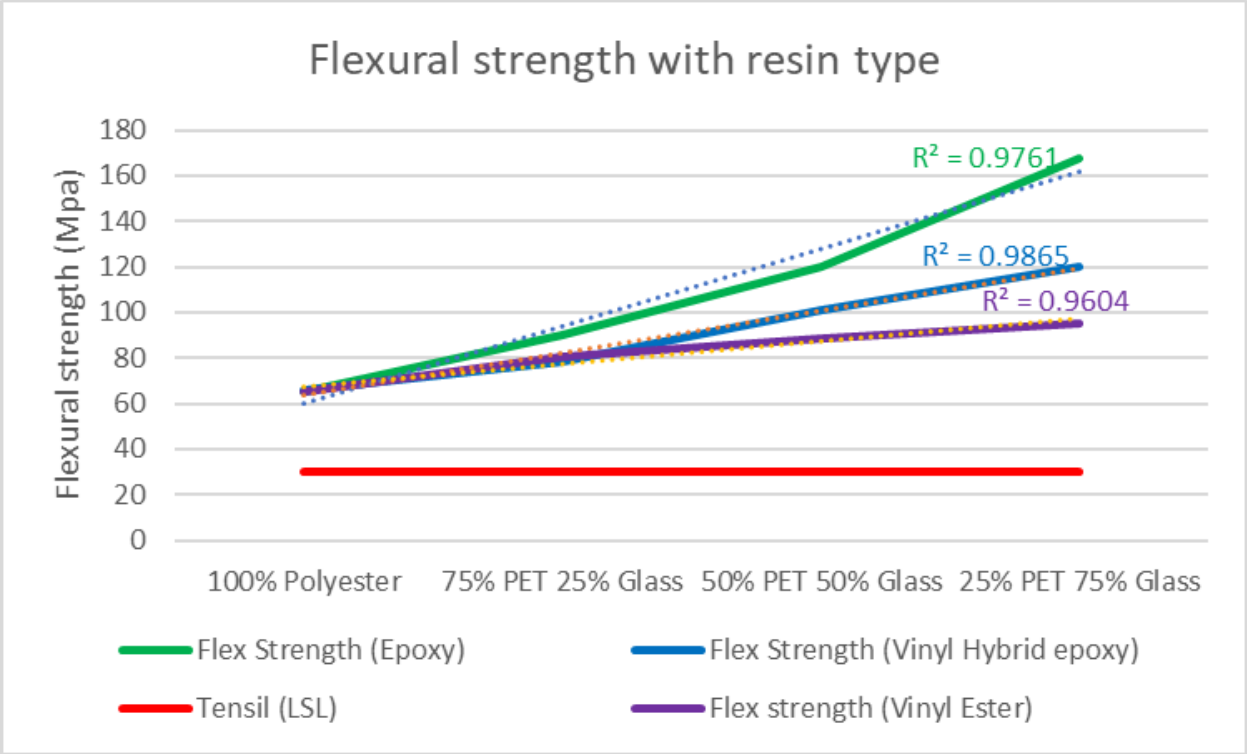


Modulus improved ~38% with 50% glass and vinyl ester resin.
Modulus improved ~52% with 50% glass and vinyl hybrid resin.
Modulus improved ~67% with 50% glass and epoxy resin.

Hybrid felts & characterization – Flexural Strength

The flexural strength also moves significantly with glass inclusion and resin type.

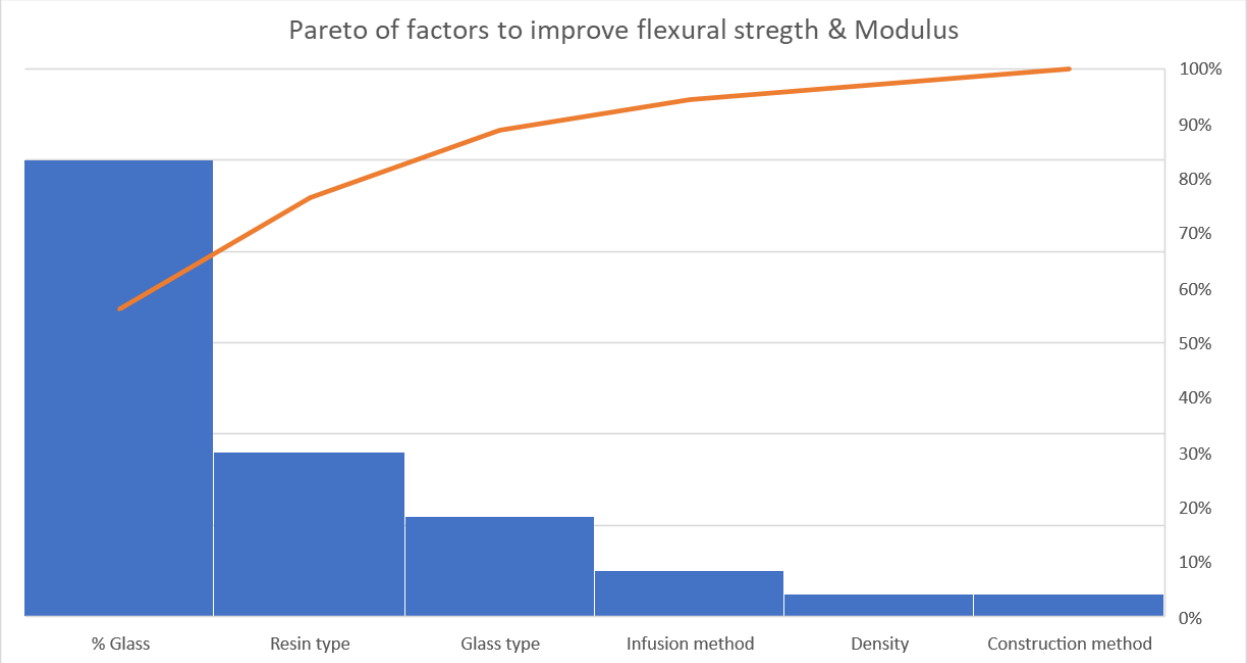
Felt consisting of 100% Polyester has the lowest result in Flexural Strength using each of the three resin types. Hybrid felt consisting of 75/25 Poly/Glass, 50/50 Poly/Glass and 25/75 Poly/Glass improved in Flexural Strength respective to the type of resin used.



Flexural strength improved ~36% with 50% glass and vinyl ester resin.
Flexural strength improved ~54% with 50% glass and vinyl hybrid resin.
Flexural strength improved ~85% with 50% glass and epoxy resin.

Optimizing Hybrid felts

Development of the hybrid felt consisted of several aspects to optimize the best combination. The controlling factors of the overall manufacturing process from raw felt to finished tube were considered. These aspects include the following areas: The ratio of glass staple fiber in relation to the felt. The type of resin used and the results of each resin in relation to the felt and glass ratio. Different glass fiber types were tested to find the optimum combination, including commonly available and glass typically specified for pipe relining. Different methods of felt wet out or resin infusion were tested. Factors of the felt density and arial weight used in the industry. The construction method used to make the hybrid felt.



Optimizing glass percentage, resin type and glass type produces the desired performance & savings.

Hybrid felts – Value proposition

In the final CIPP tube product, how much of the composite is resin and how much is fiber?
In burn-off tests after infusion, the resin is generally 80-90% weight and the fiber is generally 10-20% weight.
Resin can cost up to 5X or more the equivalent of the fiber portion of the product.
Saving resin costs therefore is key.
With flexural strength and modulus being key components of the final product, this performance boost makes savings on resin possible.

Hybrid felts – Cost example

Assumptions

- Liner cost per foot = $2.20 (Felt, coating, seaming & sealing)
- Resin cost per pound = $9
- Resin % weight per linear foot = 85%
- Felt base weight = 12opsy
- The CIPP diameter = 8”

Calculations

- Felt material weight = 0.174 lbs (15% of total weight)
- Resin material weight = 0.96 lbs (85% of total weight)
- Resin cost would be = (0.96lbs x $9) = $8.62
- Total cost per linear foot = ($8.62 + $2.20) = $10.82

Hybrid felt

- Modulus and flexural strength improve by 50%. To get the same performance the resin content can be reduced by 33%

- Total cost per linear foot = ($5.78 + $2.20) = $7.98
- Total savings of 26% or $2.84 per linear foot

Hybrid felts and other tangible benefits

UV-curable liners:

Glass fiber is transparent to light and typical UV-curable liners are made of higher cost woven glass fabrics. Compared to 100% polyester felt, Hybrid glass/polyester felts would add optical clarity to help speed cure and take advantage of the core strengthening given while reducing resin usage and material cost. UV curing trials and testing are planned for 2024.

Liner coatings:

Hybrid felts readily accept common coatings, such as PU and PVC in a variety of coating thicknesses and are easily sewn into tubes without modifying equipment or processes.

Liner installation and cure methods:

Hybrid felts can also be used in pull-in-place or inversion installations, making them ideal for hot water, steam, or UV curing processes.

Thinner liners:

Using hot water, steam or UV, thinner liners could be used to provide the equivalent strength with additional flow capacity due to reduced inside pipe diameter. Thinner, stronger hybrid felt liners also lend themselves to smaller diameter pipe rehabilitation.

Hybrid felts – Repeatability and Sustainability – EnviroLiner® (Patent Pending)

Hybrid felt material combines industry standard types of readily available polyester and fiberglass. Existing supply channels are utilized resulting in consistent sustainable manufacturing. Coating and seaming and sealing the hybrid felt material into desired tube dimensions results in repeatable supply.

Future Sustainability

Further cost reductions & sustainability may be gained by using recovered glass from end-of-life wind blades. Approximately 3000 wind turbine blades are de-commissioned each year and destined for landfills.

Tex Tech and Innovations Amplified have partnered with TPI Composites, the world's largest manufacturer of wind turbine blades, and Carbon Rivers, developer of composite fiber recovery processes, to investigate producing hybrid CIPP liners using recovered glass fiber content. Manufacturing trials and mechanical testing will commence in the first quarter of 2024.

Conclusions

Material costs for CIPP rehabilitation have been rising constantly in recent times. Planning a response to the rising costs of the two major constituents used in pipe rehabilitation impacts how a municipality prioritizes and plans infrastructure projects effecting their citizens. Implementing the use of hybrid felt materials can create a pathway for funding dollars to be used towards an expanded number of infrastructure projects.

Hybrid felt materials have improved flexural strength up to 160% (with 75% glass content) and flexural modulus up to 95% (with 75% glass content). These results expand the use of the

hybrid felt material to include projects with unique or complex requirements not met by traditional felt or multi layered hybrid felts.
Feasibility of a repeatable and sustainable hybrid felt material is practical. The patent pending process using staple polyester and glass fibers does not change the handling characteristics of the liner.
Cost efficiencies of 25 to 35% on liner and resin systems materials is achievable. This is the equivalent to $3 to $4 per linear foot on an 8” CIPP product.
Significant sustainability in the pipeline for 2024 products with ongoing development using reclaimed glass fibers.

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