

Hybrid felts can improve
overall CIPP liner strengths
and reduce costs

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UNDERGROUND CONSTRUCTION TECHNOLOGY
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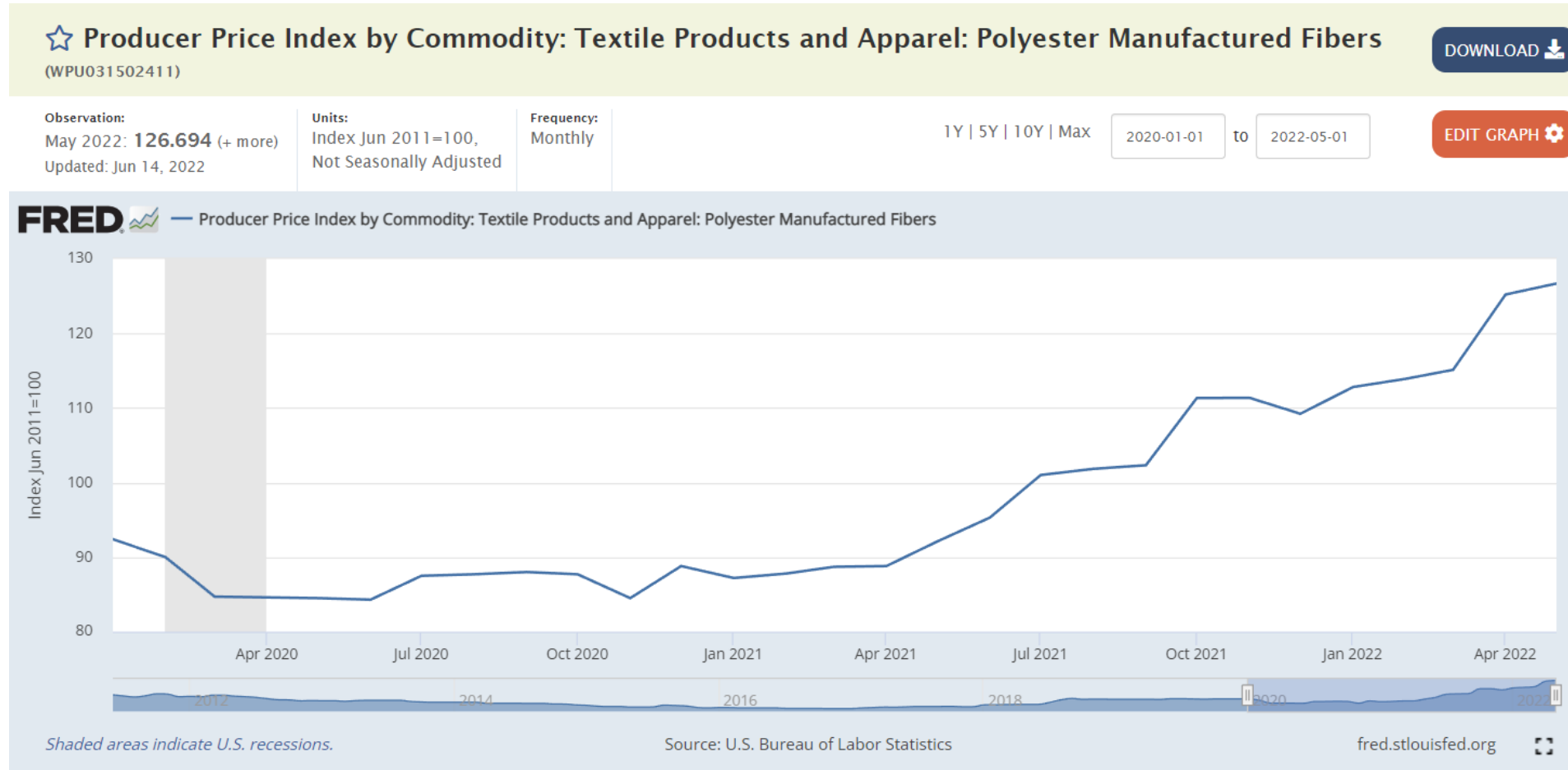
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- Raw material trends – Rising costs are rampant
- Historical felt usage in the CIPP industry
- Hybrid felts and performance increase
- Hybrid felts – Value proposition
- Hybrid felts and other tangible benefits
- Conclusions



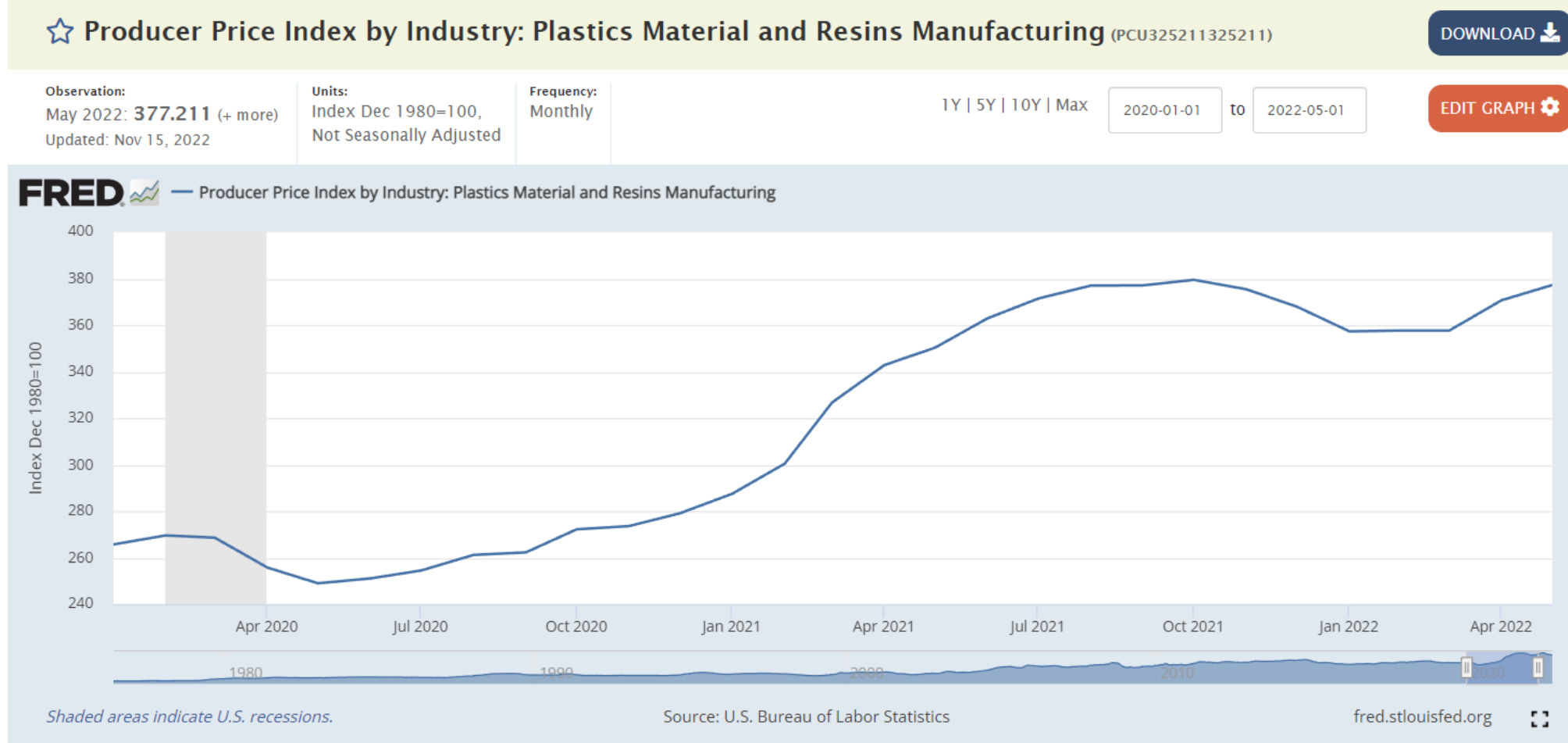
Raw material trends – Rampant rises

- Comparing the constituent raw materials that are the building blocks of CIPP (Polyester fiber & plastic resins)
- Polyester has risen ~37% from Jan 2020 to May 2022



Raw material trends – Rampant rises

- Plastic resin has risen ~42% from Jan 2022 to May 2022



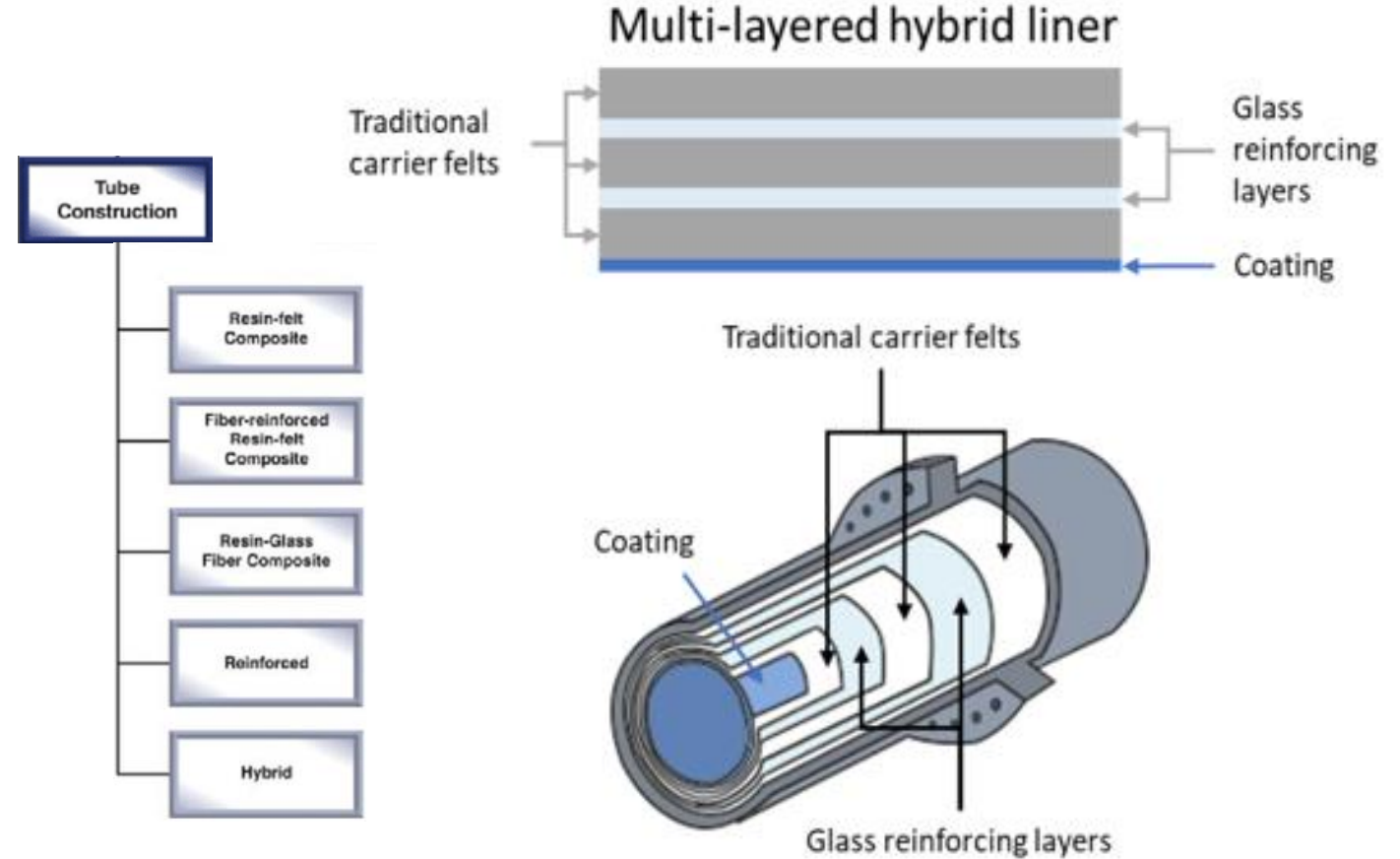
Raw material trends – Rampant rises

- Glass & glass products have risen ~13% from Jan 2022 to May 2022



Traditional CIPP methods & materials

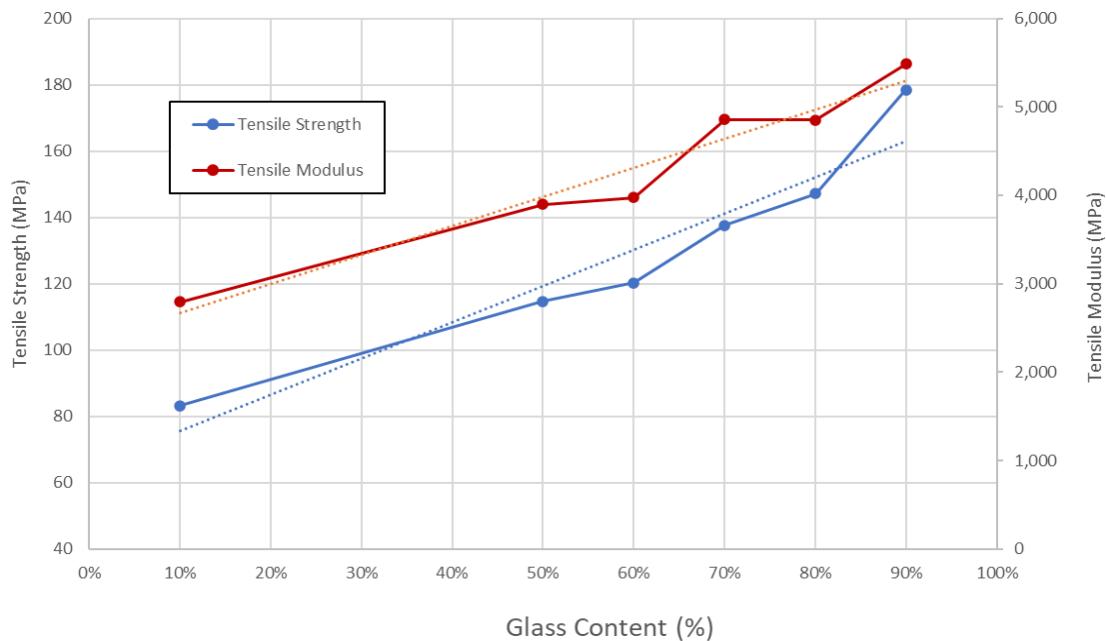
- Traditional CIPP felts utilize 100% polyester as the carrier fiber
 - It adds little to no strength
- Woven glass or glass matt layers are added to meet strength requirements where appropriate
- An alternative option is to blend less-expensive staple glass fiber (Compared to woven glass) to the polyester fiber during the needle-punching process



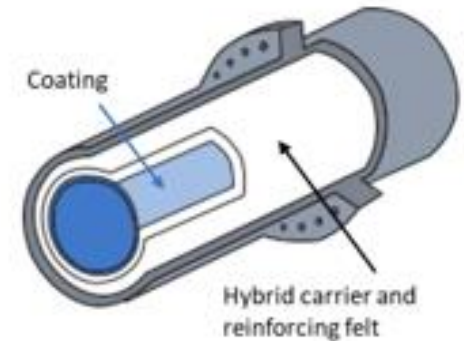
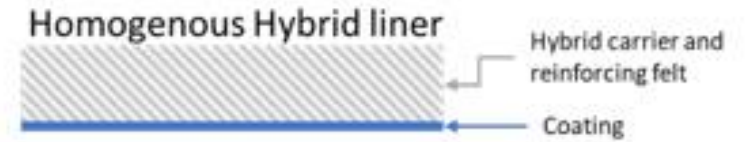
Hybrid felts & the benefit

- In-line blending of staple polyester & staple glass at various percentages was performed and ASTM D-790 was tested on the finished, resin-infused felts
- Initial results were very promising.....

ASTM D790 Flexural Test Results

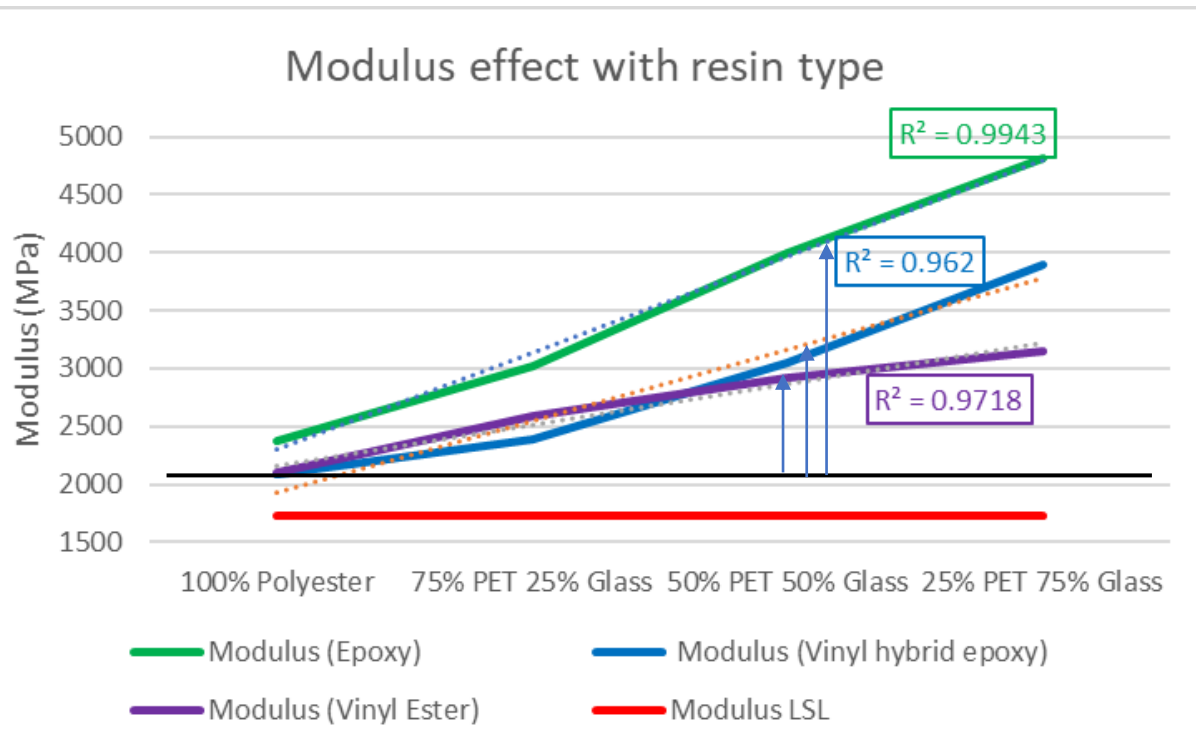


- The flexural strength showed ~ a 2X improvement with 50% glass blended
- The modulus showed ~60% improvement with 50% glass blended



Hybrid felts & characterization - Modulus

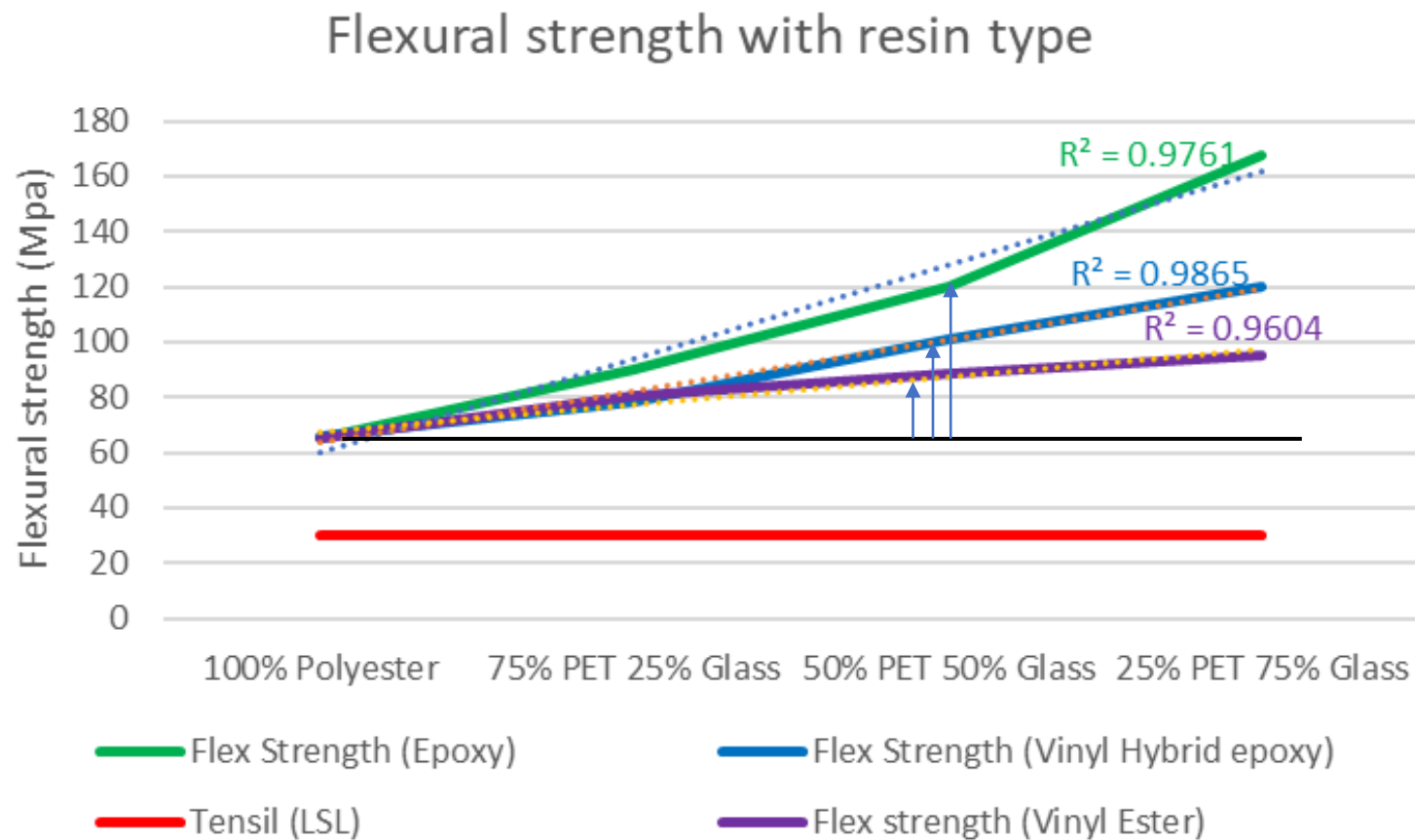
- There are many factors that can impact the performance for the flexural strength & modulus performance
- These first factor that was investigated was the resin type. Resins vary greatly in price & performance



- The modulus improved ~38% with 50% glass and utilizing the vinyl ester resin
- The modulus improved ~52% with 50% glass and utilizing the vinyl hybrid epoxy resin
- The modulus improved ~67% with 50% glass and utilizing the epoxy resin

Hybrid felts & characterization – Flexural Strength

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



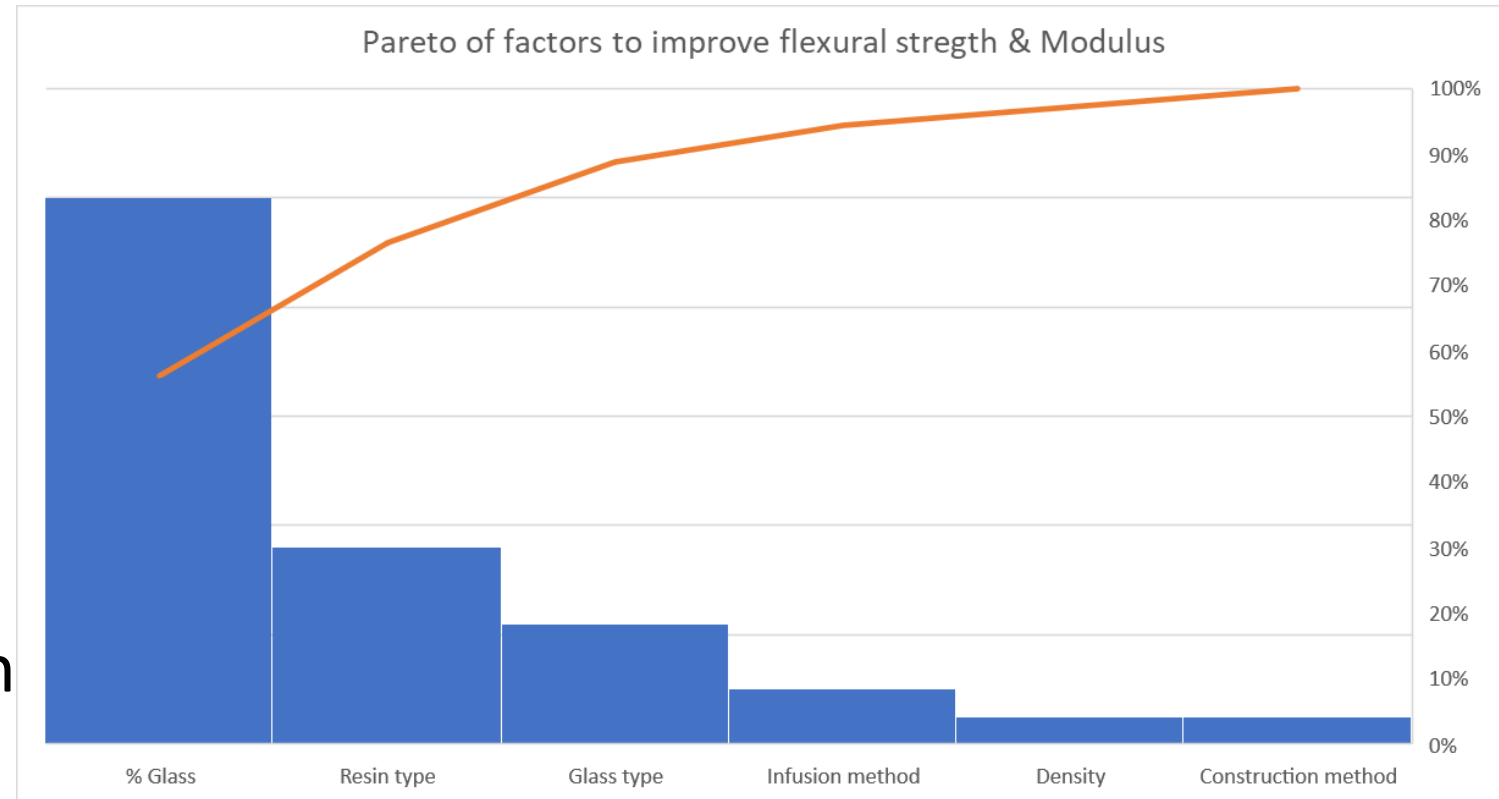
- The flexural strength improved ~36% with 50% glass and utilizing the vinyl ester resin
- The flexural strength improved ~54% with 50% glass and utilizing the vinyl hybrid resin
- The flexural strength improved ~85% with 50% glass and utilizing the epoxy resin

Hybrid felts and what are the major factors?

- We began looking at all other factors that can be controlled in the overall manufacturing process to make a finished CIPP tube

- Glass staple fiber percentage
- Resin type
- Glass fiber type
- Infusion method
- Felt density
- Felt construction method

Optimizing glass percentage, resin type, glass type should give optimized performance & savings



Hybrid felts – Value proposition

- In the final product, how much weight is resin and how much is fiber?
- In burn-off tests after infusion, the resin is generally 80-90% weight and the fiber is ~ 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 – Financial example (8" pipe)

• Assumptions

- Liner cost per foot = \$4.50 (Felt, coating, seaming & sealing)
- Resin cost per pound = \$12.60
- Resin % weight per linear foot = 85%
- Felt base weight = 12opsy
- The CIPP diameter = 8"
- Modulus & Flexural strength increase by 50%



Hybrid felts – Financial example

- 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 = $(0.96\text{lbs} \times \$12.60) = \12.10
- Total cost per linear foot = $(\$12.10 + \$4.50) = \$16.60$

- Hybrid felt

- Modulus and flexural strength improve by 50% then to get the same performance the resin content can be reduced by 33%
- Total cost per linear foot = $(\$8.11 + \$4.50) = \$12.61$
- Total savings of 24% or \$3.99 per linear foot



Hybrid felts – other tangible benefits

- Glass fiber is transparent to light (UV-curable liners are woven glass)
- Hybrid glass/polyester felts would add optical clarity (Compared to polyester only) to help speed cure and take advantage of the core strengthening given (Reduce resin usage)
- Thinner liners could be utilized that would provide the equivalent strength providing additional flow capacity – especially evident with smaller diameter pipes



Hybrid felts – Sustainability – Enviro-liner

- Further cost reductions & sustainability may be gained by utilizing re-cycled glass from end-of-life wind blades
- TPI (World's largest manufacturer of wind turbine blades) looking for sustainability options rather than land-fill (~3000 blades de-commissioned per year)
- Partnered with Carbon Rivers to develop recyclability processes
- Textech/Innovations Amplified partnering with TPI to develop in 2023



Conclusions

- Costs have been rising constantly in recent times
- Hybrid felts can improve modulus by up to 95% (With 75% glass)
- Hybrid felts can improve flexural strength by up to 160% (With 75% glass)
- Feasibility & repeatability proven for hybrid felts
- The process is extremely well characterized
- A provisional patent has been applied for based on substrate felt
- Cost savings on liners & resin system materials of 25-30% achievable
- Equivalent to ~\$4 or higher per linear foot on an 8" CIPP product
- Significant sustainability in the pipeline for 2023 products

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