AMPP Corrosion 2022

Toward Objective Evaluation of FRP Corrosion Barrier Condition

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Purpose

Provide a methodology that is based on existing consensus standard practices for robust, reliable and objective engineering condition assessment of corrosion barriers in FRP.

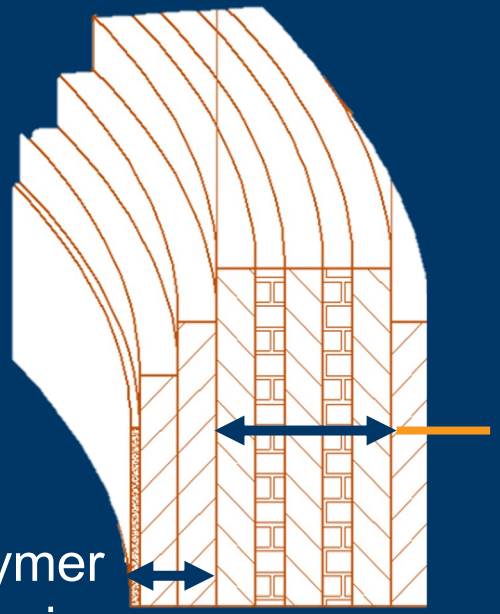
Plan

- Applications & Construction
- Information from Chemists
- Damage Summary
- Engineering
- Conclusions

Applications

- 200+ Engineering & Construction Standards
  - use material strength and service conditions for design

Proven Construction for Reliability



Polymer or Resin:

- **50% to 95% of the total volume**
- **Provides 100% of corrosion resistance**

Polymer Qualification

- Recommended by most construction standards
- *Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service*
  - **ASTM Designation C 581**
- In use for almost 50 years
- Coupons ~85% polymer

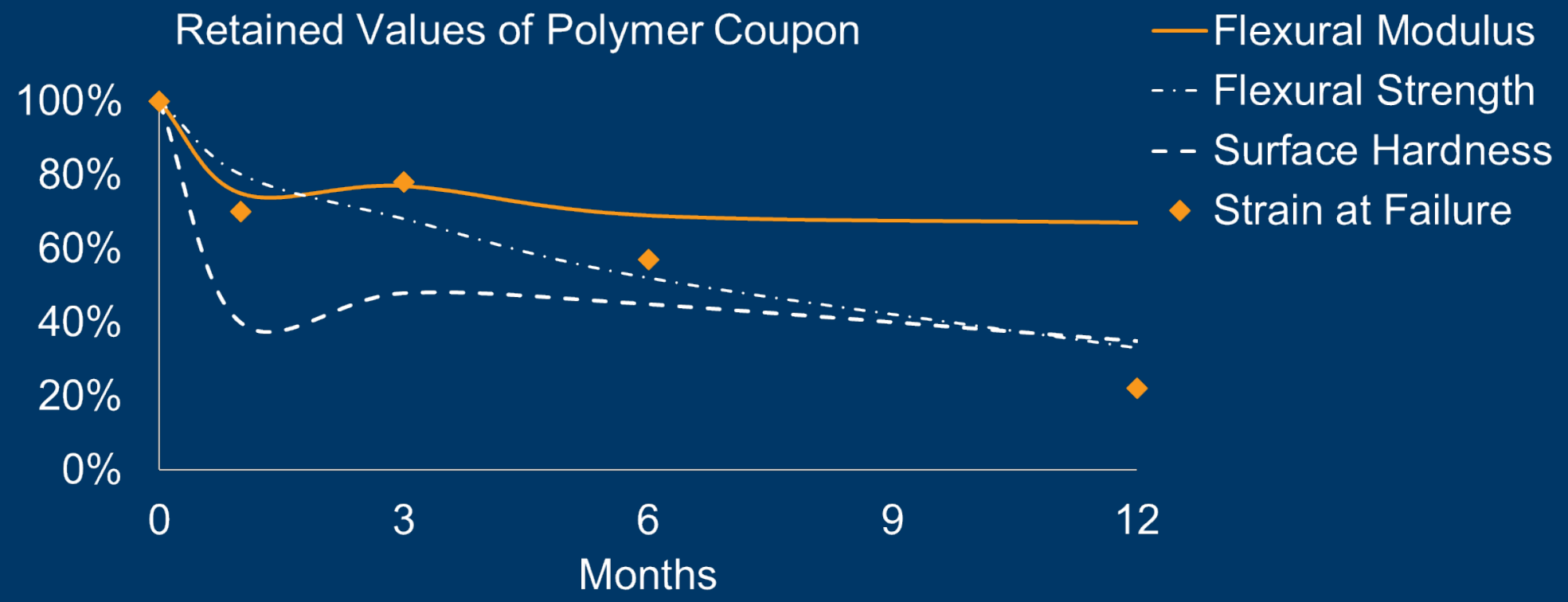
Polymer Qualification

Parameter	Immersion Period (months)				
	0	1	3	6	12
% Thickness Change					
% Weight Change					
% of New Hardness					
% of New Flexural Modulus					
% of New Flexural Strength					
Appearance of specimen					
Appearance of chemical solution					

Diffusion or permeation is not measured

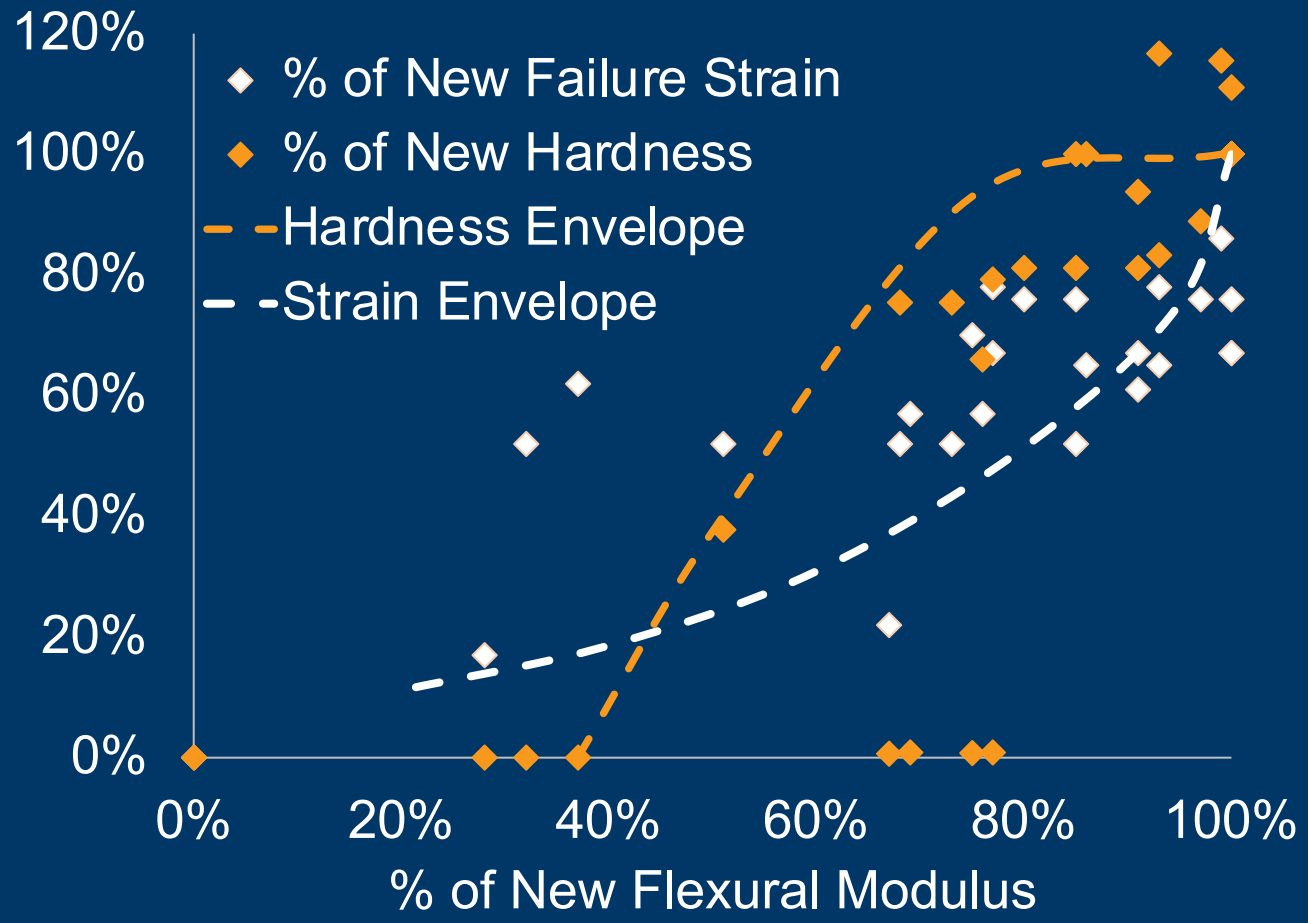
Polymer Qualification

- For one polymer in hydrochloric acid



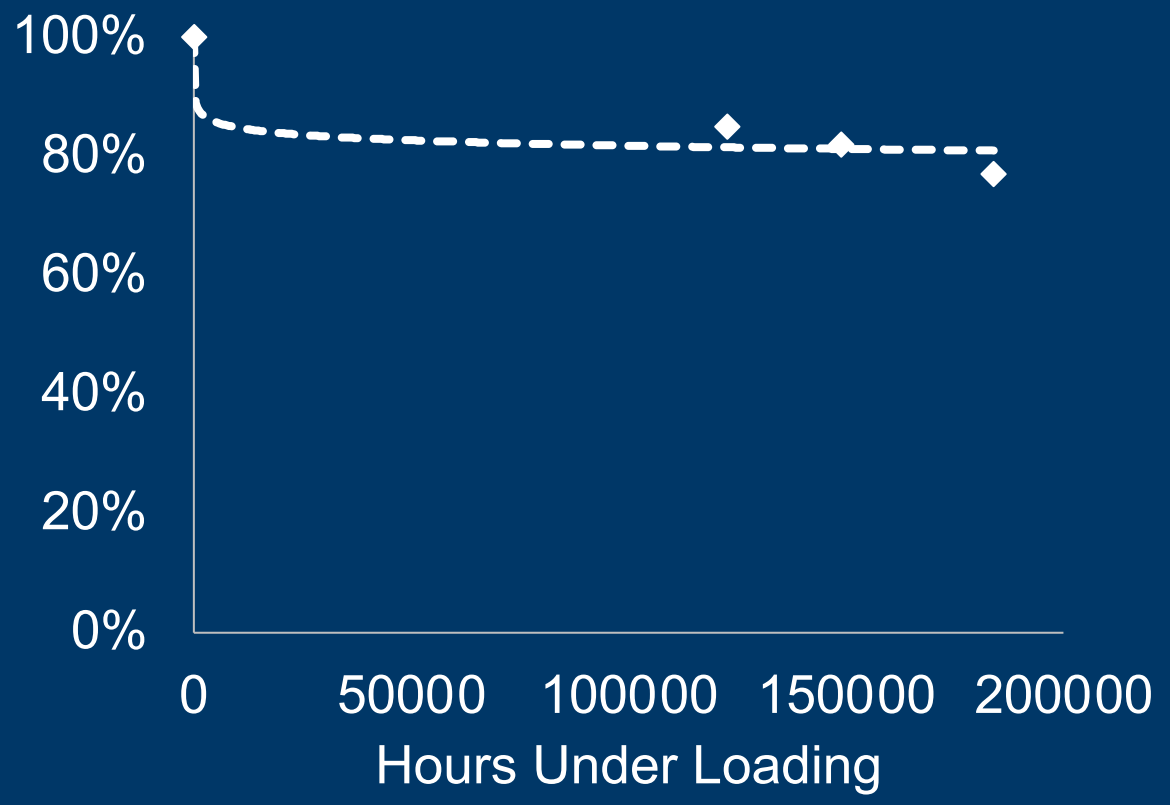
Polymer Qualification

- Combined: 2 polymers X 3 chemicals



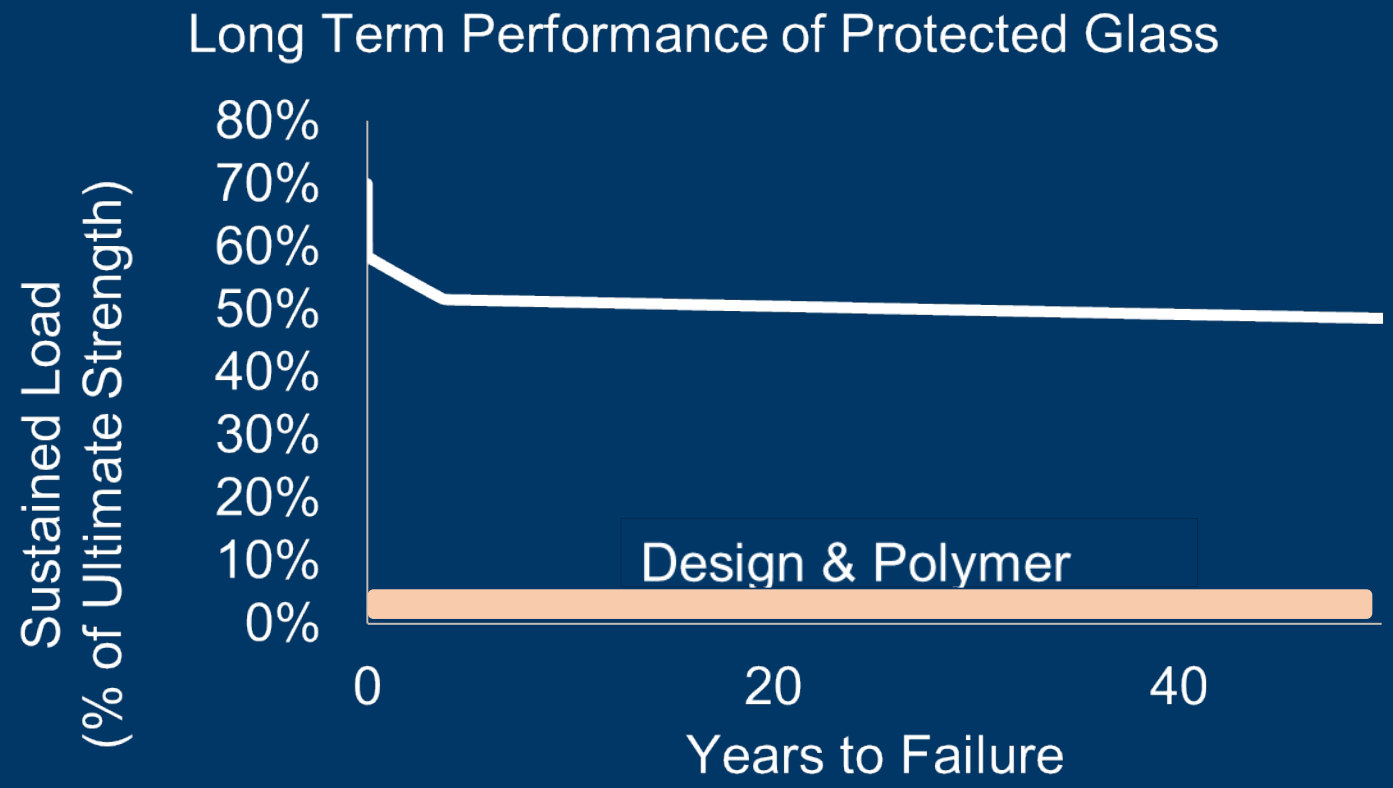
Polymer Qualification

- Mechanical stress, only
- Relates to:
  - Code EN13121
  - Pipe qualification
  - Section X qualification
- No chemical attack - no change in hardness
- Similar reduction in strain



Reinforcement glass

- Protected by polymer



Data courtesy of Owens Corning

Polymer Damage

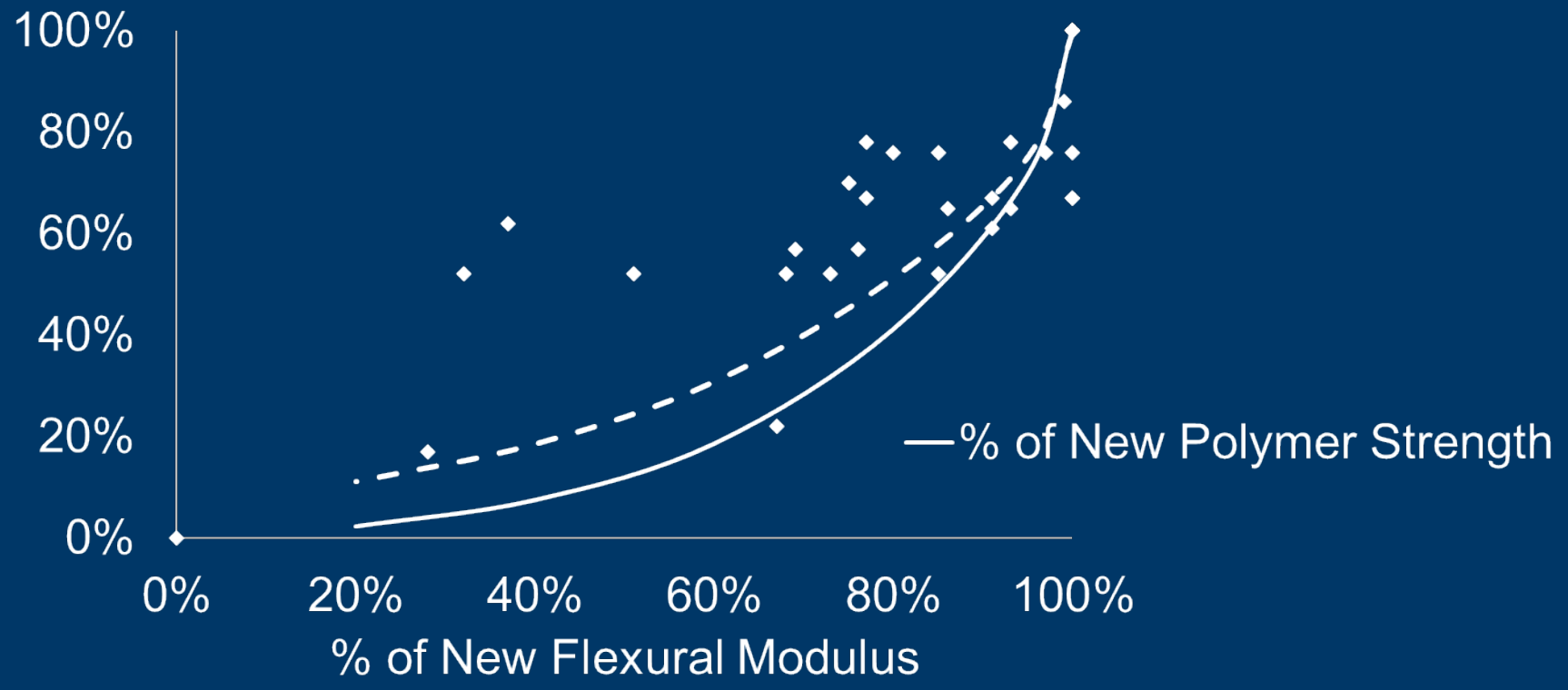
- Polymer damage happens before glass damage.
- Damage to the polymer volume is best expressed in terms of retained flexural modulus
- Damage from corrosion & mechanical stress is similar
- There is a common trend in failure strain and flexural modulus.

Engineering

- Translating chemical testing results to applications.
- Require Engineering parameters to evaluate ability to continue in service.

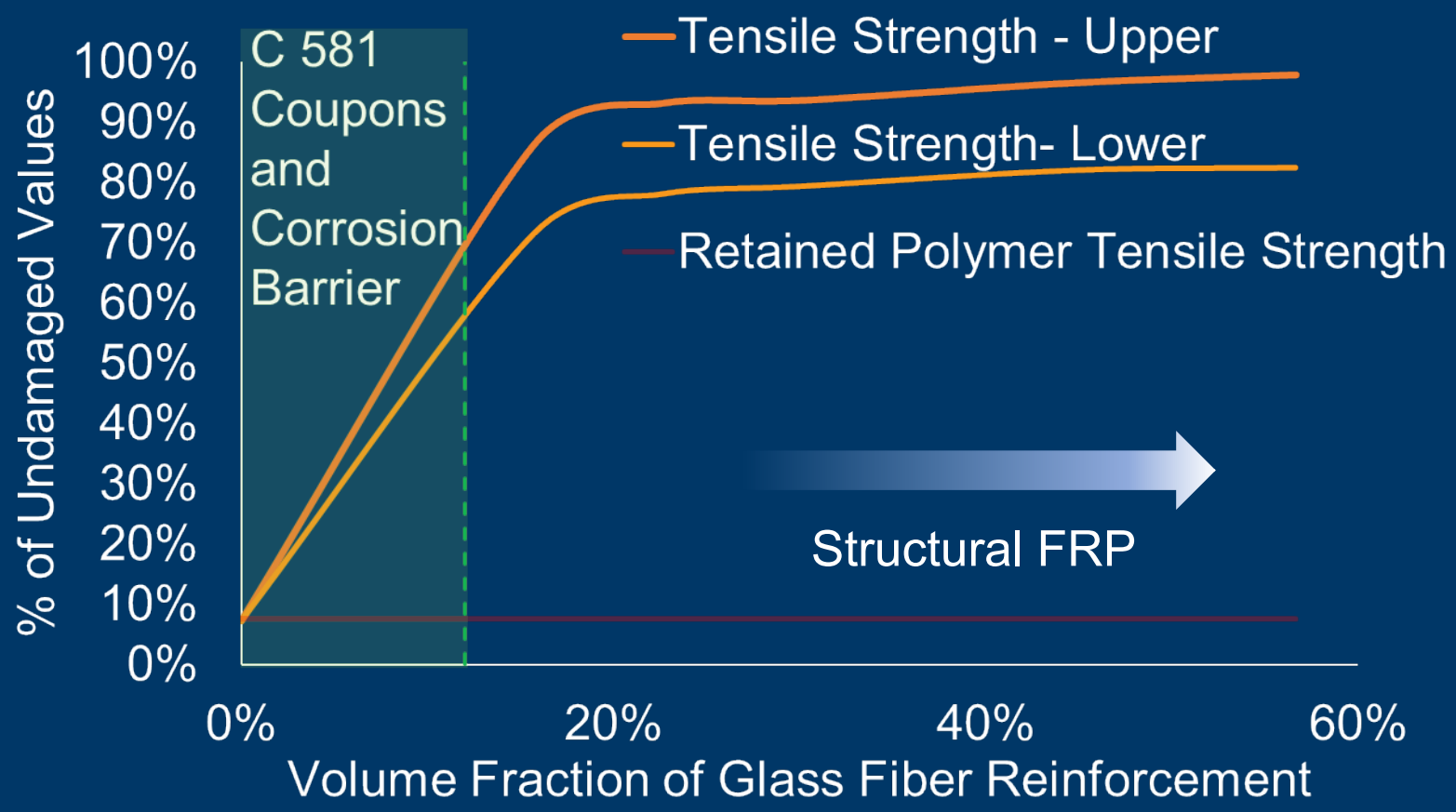
Converting C 581 Results to Engineering

- Flexural modulus ≅ Polymer tensile modulus
- Strength of Resin = Modulus x Strain at failure

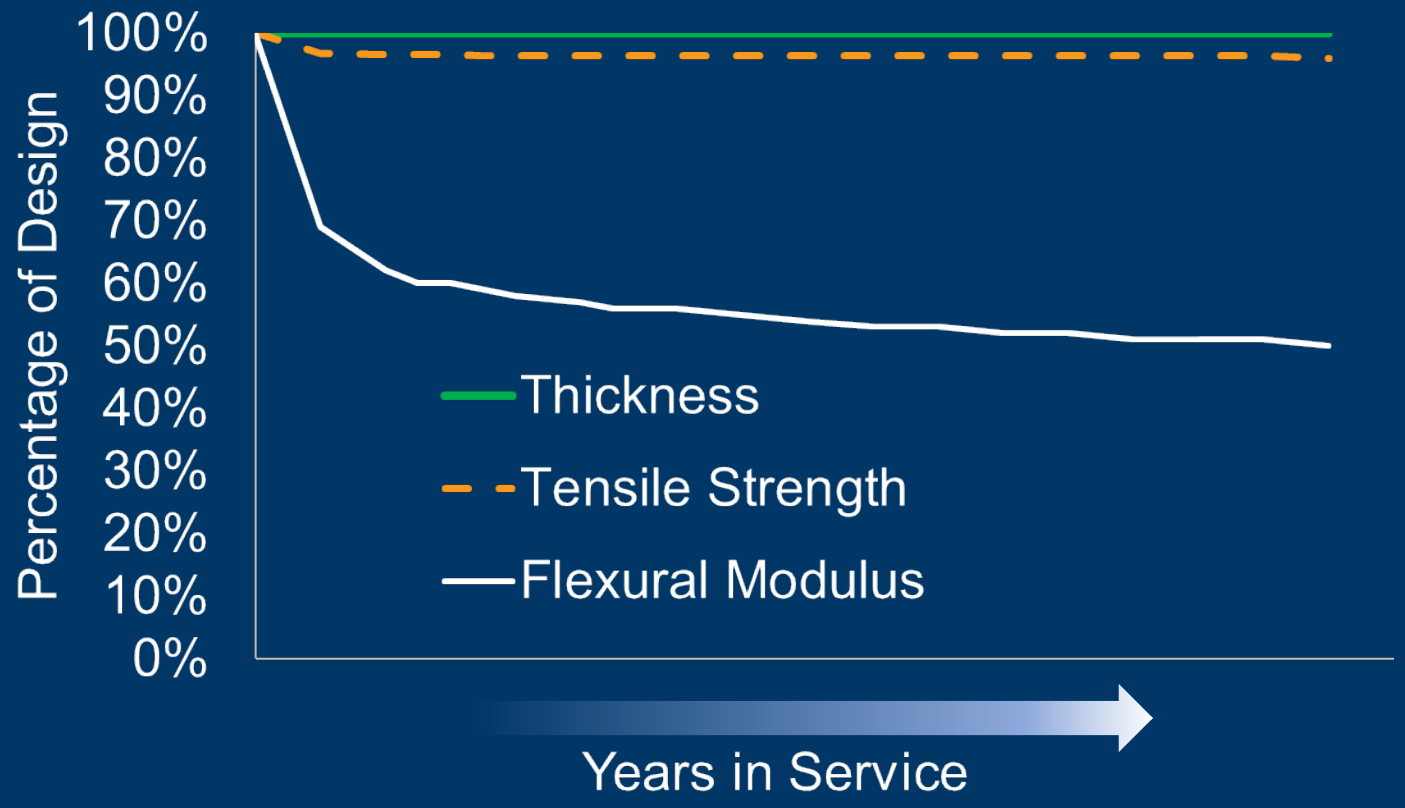


Effect on Design Parameters

- At 40% Retained Flex. Mod.

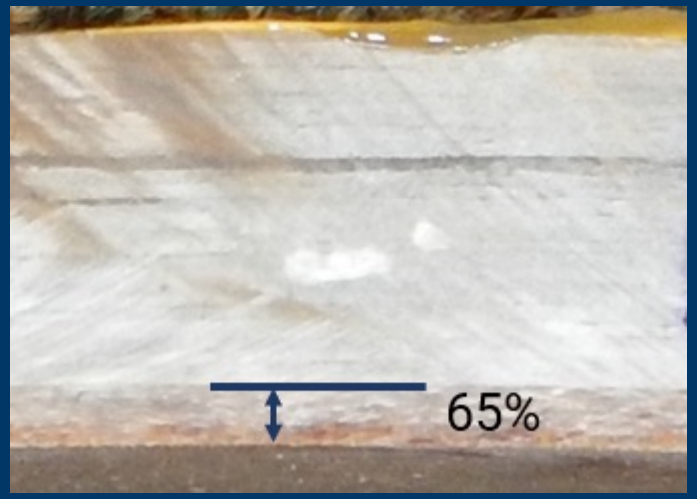


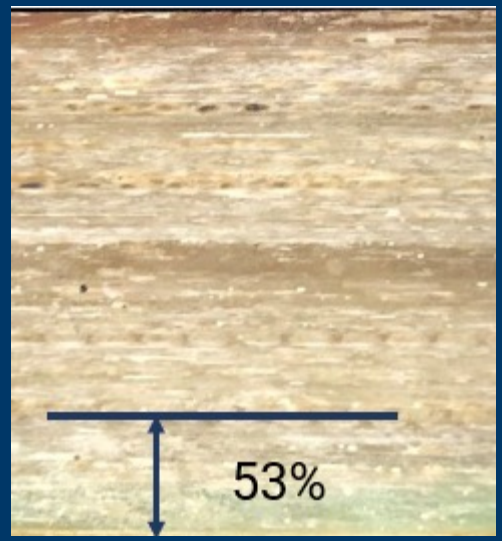
Overall Effect from Service Conditions



Objective Corrosion Barrier Condition

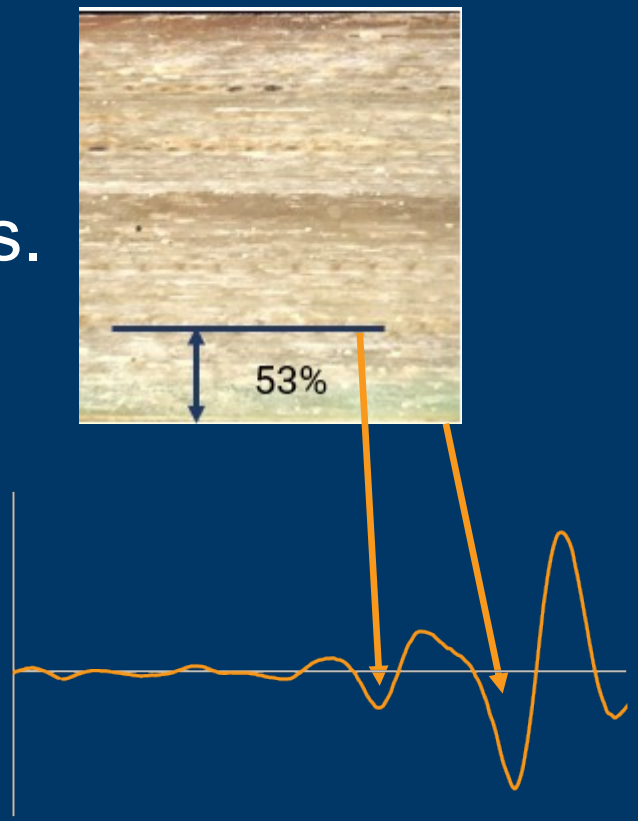
- Based on depth of damage and retained modulus of CB only.
- Assess the full damaged volume – not just surface.
- Damage might be deeper than visible





Detecting Corrosion Barrier Condition

- Destructive:
  - Remove coupon
  - Separate and test the damaged thickness.
  - Single location
- Non-Destructive:
  - Ultrasound
  - Post-processing to calculate depth and extent of damage.
  - Many locations.



How do we get there?

1. Incorporate polymer damage criteria from C 581 testing.
2. Provide “End of Service Life” criteria for the polymers used. Trend lines can give conservative values.
3. Expand calculations to show effect of polymer damage.
4. Use NDT to determine damage depth and condition of polymer.

Conclusions

- Current design and construction do not incorporate material properties that change due to damage.
- Results of existing standardized polymer tests can allow existing standards to be adapted for FFS.
- Existing calculations can also be used to determine effects of damage.
- Non destructive testing is required to measure the damage.

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Questions

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