# Impact of Wood Preservative Treatments on Mechanical Properties of E-glass/Phenolic Composite (FRP) Reinforcement for Laminated Wood Beams

*by*

*Cihat Tascioglu*[1]

*Barry Goodell*[2]

*Roberto Lopez-Anido*[3]

[1]Duzce University, [2]Virginia Tech, [3]University of Maine

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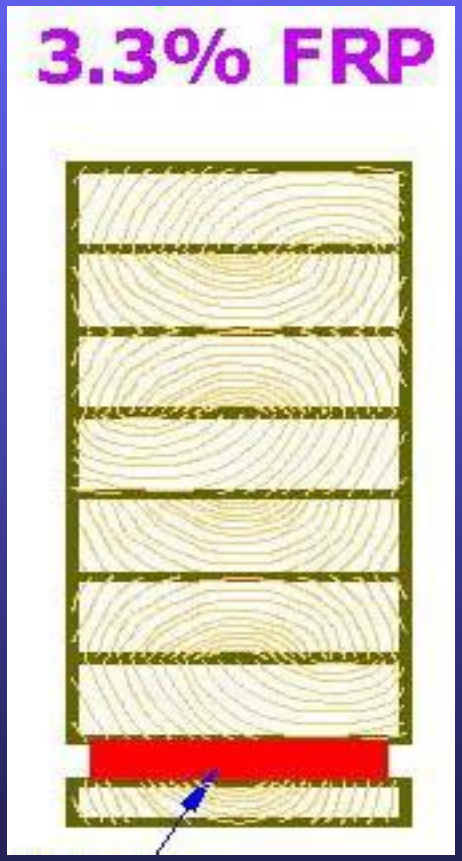
# Material Description

- **Fiber Reinforced Polymers (FRPs);** consist of fibers of high strength and modulus embedded in or bonded to a matrix.
  - *Fibers*: glass, carbon, aramid, boron etc.
  - *Matrix*: phenolic, epoxies, polyethylene, vinyl ester, other thermoplastics and thermosets

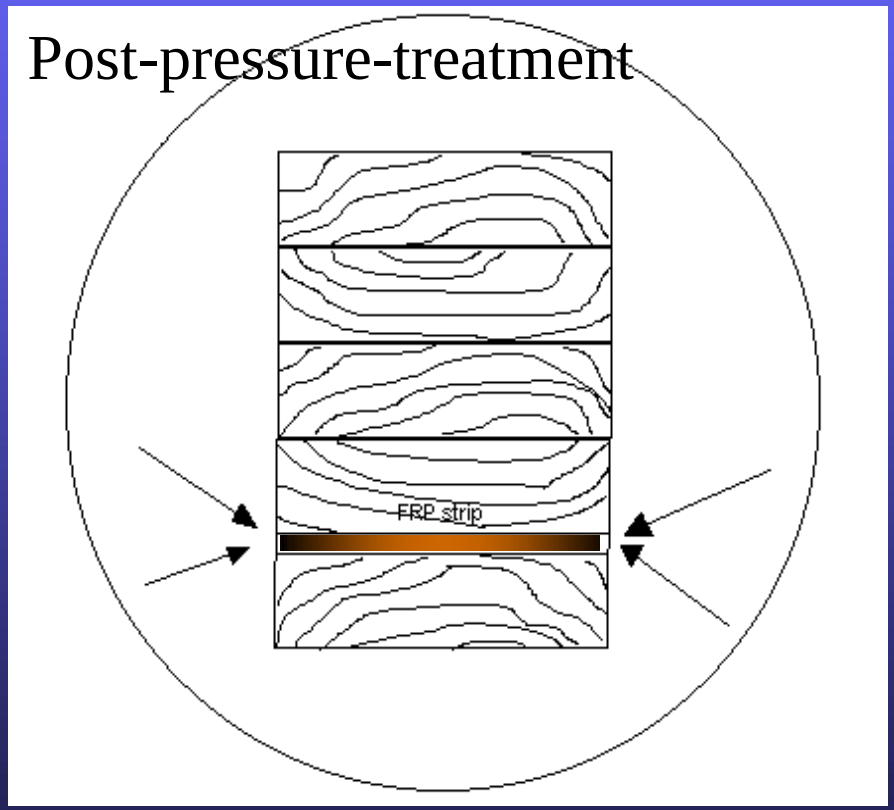
- **Advantages when used as wood reinforcement?**
- Increased strength and stiffness
- Increased ductility, which provides a safer failure mechanism
- Improved creep characteristics
- Use of low-grade wood in construction
- Reduced cost
- Improved serviceability

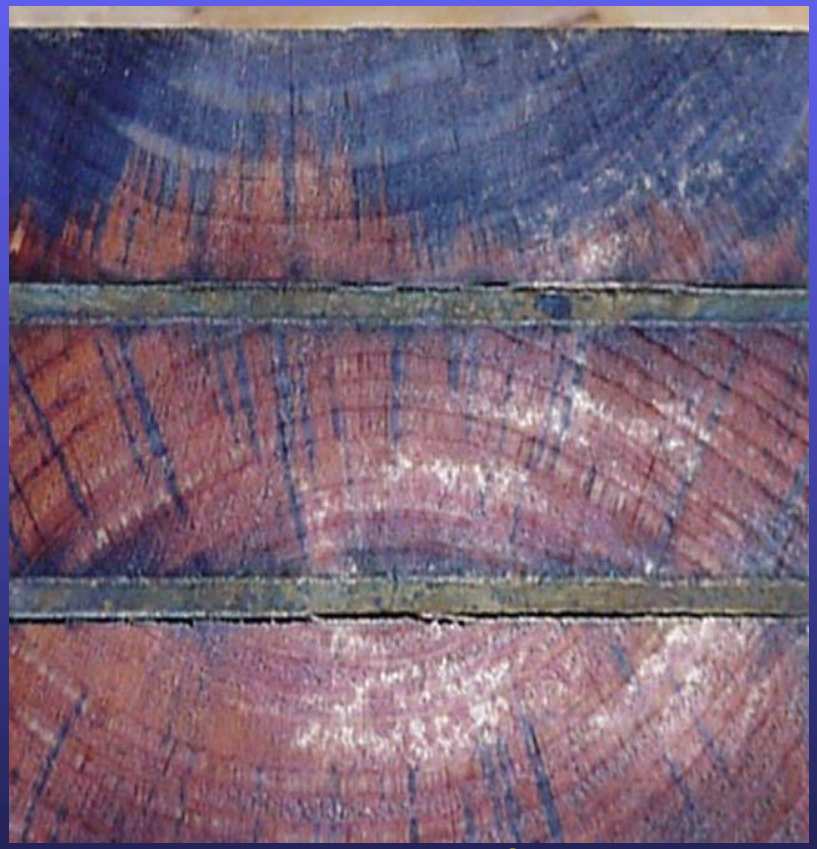
# Practical applications of wood/FRP hybrid materials:

Pressure treated FRP reinforced glulam bridges




# How does FRP material get exposed during the pressure treatment ?



Cross section of a cyclic delamination specimen

# General Objectives

- To determine the effects of wood preservative treatments on the mechanical properties of FRP material.
- To determine a compatible preservative treatment chemical or system for FRPs
- Provide recommendations for the preservative treatment of wood /FRP hybrids

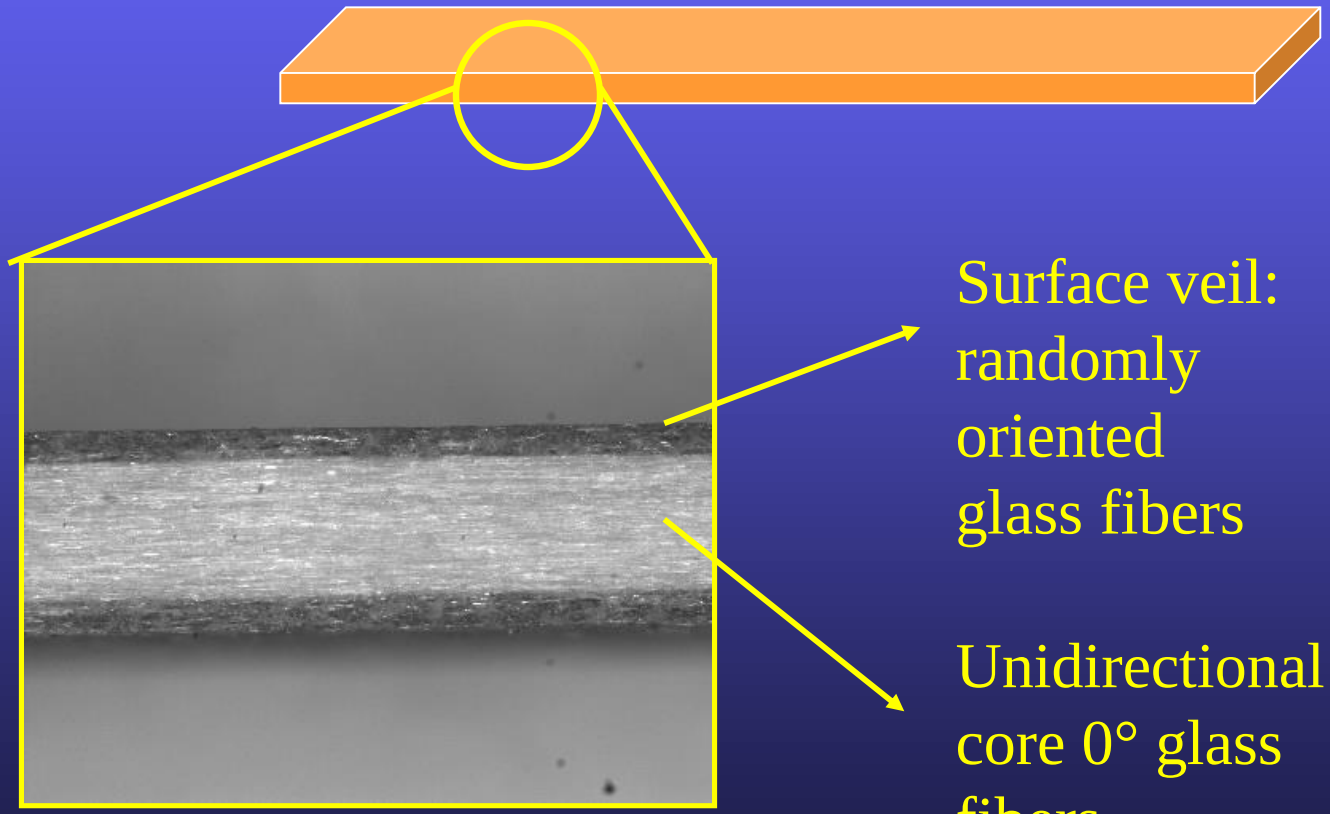
# Materials & Methods

- Determination of void content of FRPs:
  - ASTM D-2584 and D-2734 ignition loss tests
  - Digital image analysis and measurements
- Preservative / Pressure Treatment of FRP
- Mechanical tests
  - ASTM D-3039 Long. and transversal tensile strength
  - ASTM D-2344 Interlaminar shear strength
- Microfailure analysis: Light and electron microscopy imaging of FRP and glass fibers.

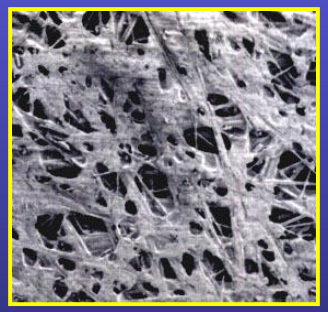
# Features of FRP

Material: E-glass fibers and phenolic resin

Density : 1.6 g/cm$^3$ Production Method : Pultrusion



Surface veil: randomly oriented glass fibers

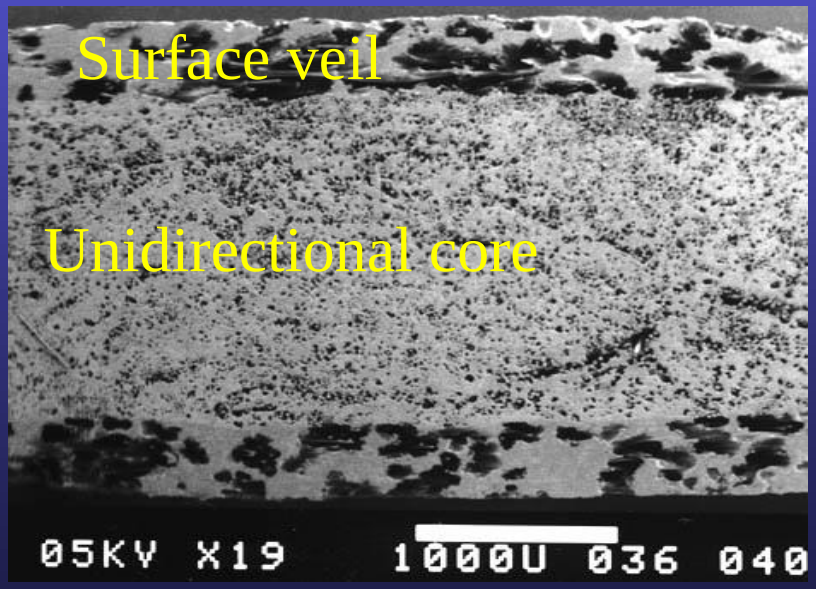


Unidirectional core 0° glass fibers

# Void Content

| Volume Fraction (%) | Veil | Core |
|---|---|---|
| Fiber | 24 | 70 |
| Matrix | 38 | 12 |
| Void | 38 | 18 |

- **<u>Void content affects:</u>**
- Preservative uptake and penetration
- More surface area to interact with chemicals




Cross section

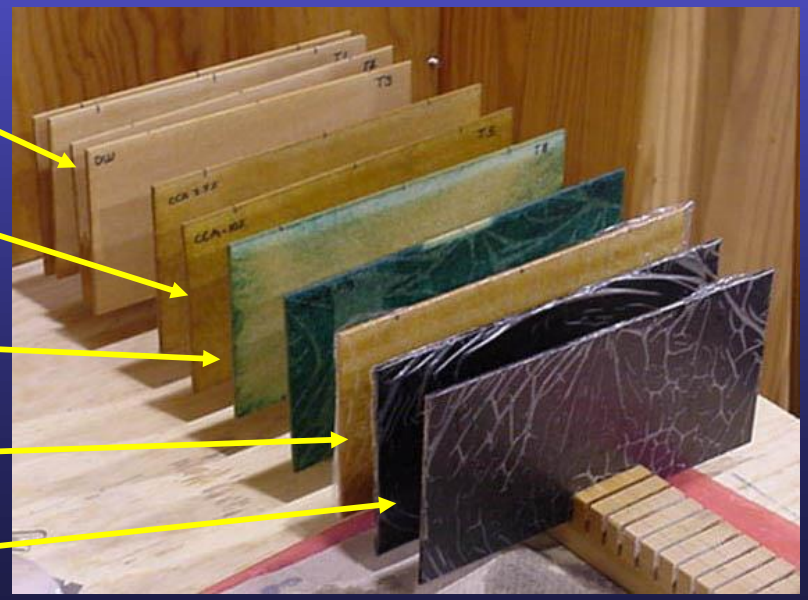
# Preservative chemicals and treatment

Treatment method: Full-cell (Vacuum, pressure, vacuum)

| Preservative | CCA-C | CDDC | Cu-N | PCP | Creosote |
|---|---|---|---|---|---|
| Low con. | 2.5% | 2.5% | 0.5% | 5% | 100% |
| High con. | 10% | 5% | 2.5% | 10% | 100% |

Specimen size:
32 x 120 x 254 mm

End-sealed

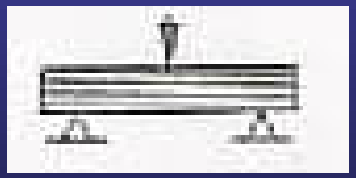


# Retention table of treatments

| Treatment | **Solution pick-up (%)** | Retention (pcf) | pH |
|---|---|---|---|
| Untreated | **0** | 0 | - |
| Water | **14** | 0 | 7 |
| CCA (in water) | **15** | 0.37/1.56 | 2-2.5 |
| CDDC (in water) | **17** | 0.44/0.84 | 11 |
| Cu-N (in mineral spirits) | **13** | 0.07/0.31 | N/A |
| PCP (in diesel fuel) | **16** | 0.85/1.57 | N/A |
| Creosote | **17** | 16.21 | N/A |
| Average | ***15.3*** | | |

→ Compare with core void volume **18%** , indicating the treatments filled 85% of the void volume in FRP

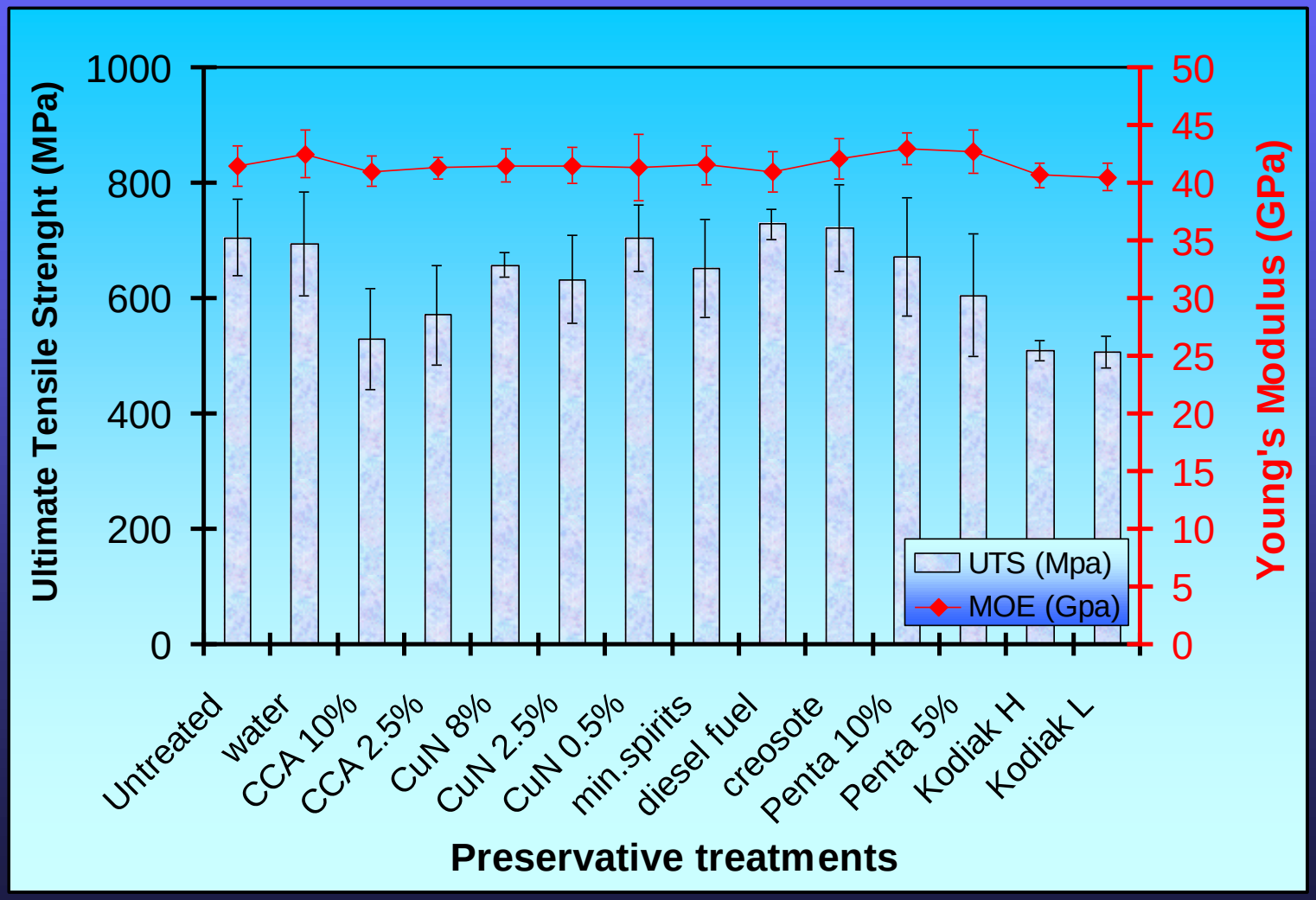
# Test methods for mechanical characterization of preservative treated FRP

| Tested Property (ASTM Standard) | Specimen Configuration | Elastic Properties | Strength parameters | Dominating component |
|---|---|---|---|---|
| **Longitudinal Tension**<br><br>**ASTM-D 3039** |  | Longitudinal MOE | Longitudinal tensile strength | Fiber |
| **Transverse Tension**<br><br>**ASTM-D 3039** |  | Transversal MOE | Transversal tensile strength | Matrix |
| **Interlaminar Shear (short beam)**<br><br>**ASTM-D 2344** |  | | Interlaminar shear strength | Matrix or fiber matrix interface |

# Mechanical Tests


100 kN Servo-hydraulic tester


# Effects of wood preservatives on longitudinal MOE and tensile strength of FRP

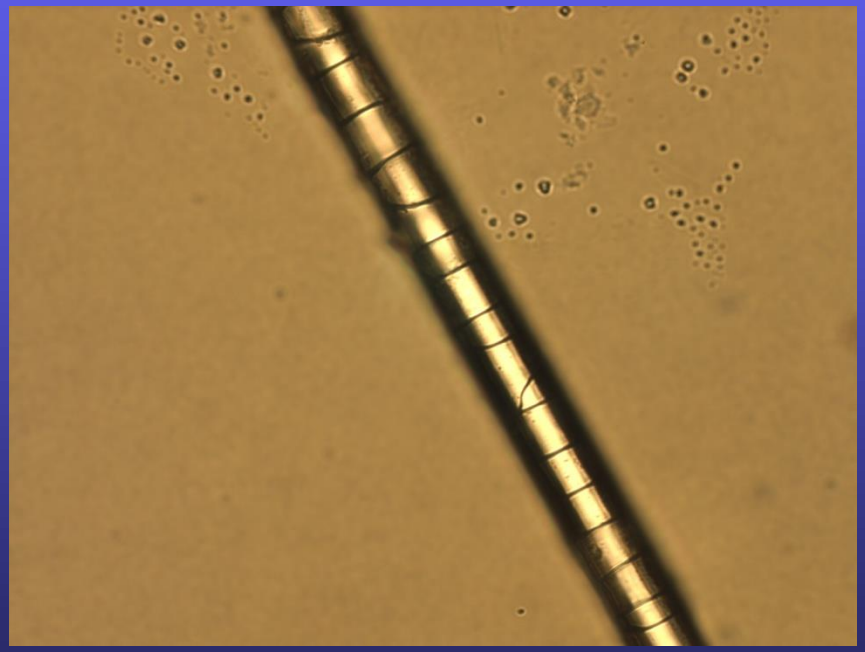


# Macro Failure Modes

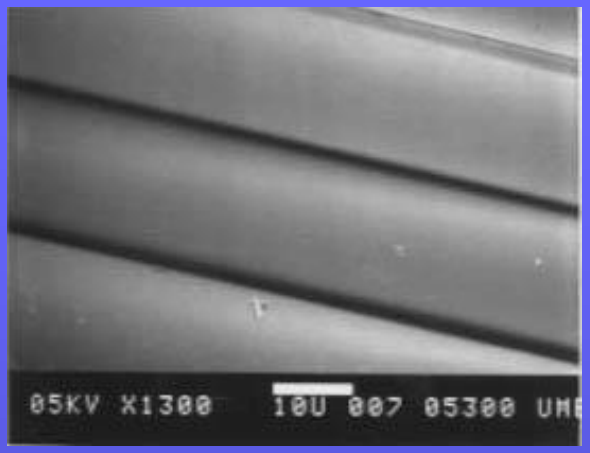
CCA CDDC PCP Cu-N Creosote Untreated

# Micro failure analysis:

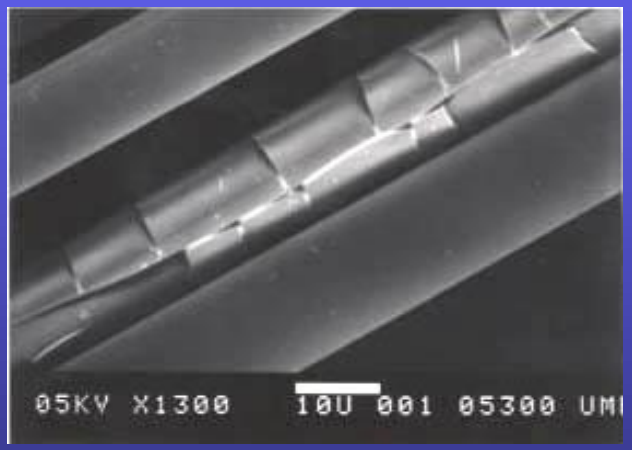
Spiral cracks and longitudinal fissures
on glass fibers taken from CCA treated coupons



# Comparison among the glass fibers treated with different wood preservatives:

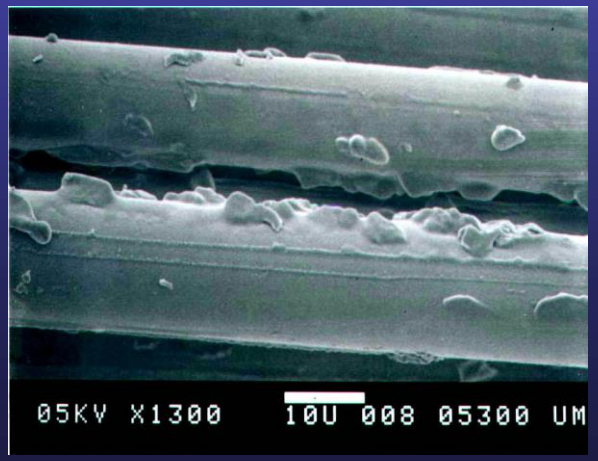



Water treated




CCA

Cu-N



# Conclusions

- Water-borne treatments caused a 25-30% loss in longitudinal strength. This reduction should be considered in design criteria.
- Increased retention resulted in an increase in strength loss for CCA-treated FRP. Retentions up to the ground contact level may be considered as the thresholds for CCA treatment.
- In general, oil-borne treatments (creosote, PCP, Cu-N) can be considered FRP-compatible.
- For all treatments, the phenolic resin matrix seemed to be unaffected by preservatives tested.

# Thank you very much !!