Commercialization of Advanced FRP Composite Materials for Poles, Posts, Pipes and Panels

Hota GangaRao, Ph.D., P.E.

Professor, Department of Civil and Environmental Engineering

Director, Constructed Facilities Center

College of Engineering and Mineral Resources

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Presentation Overview

- CFC- WVU: FRP Center of Excellence
- Why FRP in WV
- Potential Market Impact
- Technical Solutions
- Existing Applications
- Cost Analysis
- Commercialization Strategies
- Case Study: FRP Utility Poles
- Summary

West Virginia University Constructed Facilities Center (CFC-WVU)

- Established in 1988 to bridge Univ.-Gov.-Ind. efforts
- (10+2) Faculty, 6 Eng Scientists, 4 Staff, 35+ Grads
- Interdisciplinary: Civil, Chem., Elec., Indus., Mech.
- Aim:
  - To foster and conduct R & D vital to new constructions and rehabilitation of existing facilities
  - To promote and advance FRP composites for civil and military infrastructure applications
- FRP Center of Excellence (by DOT/FHWA in 1999)

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What CFC-WVU Can Offer ?

- Technology training
- Material characterization
- Destructive /nondestructive evaluation
- Field monitoring & performance studies
- Product development
- Design and prototype manufacturing

Why FRP in West Virginia (1)

FRPs constituent materials, i.e. resin systems and glass fabrics, have strong presence in and around West Virginia.

- **Resins**

  Ashland, OH; KY
  BASF, WV
  Bayer, WV; PA
  Crompton Co, WV
  Dow Chemical, WV
  DuPont, WV
  GE Plastics Inc., WV
  M & G Polymers, WV
  PPG, WV
  Proviron America, WV

- **Glass fibers**

  PPG, PA
  Owens-Corning, OH
  Saint-Gobain Vetrotex America, Inc., OH: PA

- **Polymer Alliance Zone**, Parkersburg, WV
- **Chemical Industry of Future**, Morgantown, WV

Why FRP in West Virginia (2)

WV companies associated with composite manufacturing:

- Aurora Flight Sciences, Bridgeport, WV
  - Prototype composite aircraft structures using an autoclave process
- FMW Composite Systems, Bridgeport, WV
  - A composite product manufacturer
- U.S. Navy Allegheny Ballistic Laboratory, Rocket Center, WV
  - Produce composite components for weapon systems
- RCBI Composites Technology Center, Bridgeport, WV
  - Provide training to the region's growing aviation industry

FRPs will find wide range of civil and military infrastructure applications, such as highway structures, utility poles, transportation industry, army bridging, airport runways, waterfront and naval facilities, ship hulls, aircraft carrier decks, etc.

Advantages / Limitations of FRP Composites

Being accepted as replacements of traditional materials in many applications, because of:

- Higher strength- and stiffness- to-weight ratios than steel, wood or concrete
- Higher fatigue strength & impact energy absorption capacity
- Better resistance to corrosion, rust, fire, hurricane, ice storm, acids, water intrusion, temperature changes, attacks from microorganisms, insects, and woodpeckers
- Better flexibility
- Longer service life (over 80-100 years)
- Better non-conductivity
- Lighter-weight leading to lower installation cost
- Lower maintenance cost

But, more expensive per unit weight

Our Goal

Commercialization of Advanced FRP Composite Materials for Poles, Posts, Pipes and Panels

Commercialization means "the cost–effective production and application of advanced materials to meet global market needs" - *According to* National Materials Advisory Board, National Research Council, 1993

Note: Composite bridge decks from CFC-WVU designs coupled with BRP Inc.'s production and installation capability are costing about the same amount as concrete decks on a square foot area basis, i.e. about $30 /sq ft.

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Poles, Posts, Pipes and Panels

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Prospective Market: Poles

- 130 million utility poles in-service in USA
  - 98% chemically treated wood poles
  - ~4 million poles need replacement per year
  - ~90,000 poles in WV
- $4 billion treated wood poles annually
  - $2.8 billion for replacement
  - $1.2 billion for new construction

Prospective Market: Posts

- 36 million highway signposts are in-service with an annual replacement of about 2 million posts in U.S., generating a market of $100 to 200 million

- WVDOT uses approximately 50,000 wood and 200,000 steel guardrail posts annually

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Prospective Market: Pipes

- **Extensive pipeline infrastructure in service in U.S.**
  - 161,189 miles liquid pipelines
  - 307,809 miles natural gas transmission pipelines
  - 1,100,855 miles natural gas distribution pipelines
  - 2,000,000 miles water and sewage pipelines

- **Over 50,000 miles of new natural gas transmission pipelines are being built in the 2001-2010 timeframe at a cost of over $80 billion in North America**

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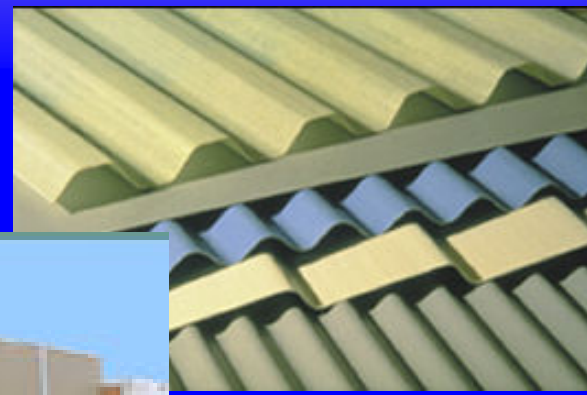
FRP Composite Panels

For extremely wide range of applications:
wall, floor, roof,
bridge decks,
marina……



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Prospective Market: Bridge Decks

- $50 billion was spent on highways and bridges in 1999
- $8.1 billion Federal funded bridge projects in 2002
- $2-3 billion estimated bridge decks annual market

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Prospective Market: Waterfront Structures

- $3.4 billion U.S. marina decking industry
- Est. 5.1 billion board feet market in 2005
  (Marina Today, July 2002)

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Opportunities for Composites in Marina Applications

-ONR Survey Report, Dec. 2000

- 62% of 11,045 U.S. Marinas w/construction activity, costing $100 million /year (materials only)
- Use of composites: about 2% (over last 5 years)
- User knowledge of composites:
  - 37% little to none
  - 35% average
  - 28% above average
- Receptivity to new tech. (composites): 80% of surveyed personnel either receptive or very receptive

Potential Market Impact

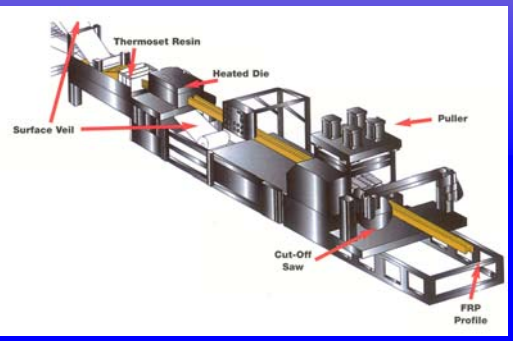
Applications	Annual market	Projected FRP market share	Projected FRP annual market
Utility poles	$4 billion	5%	$200 million
Highway Signposts	$100-200 million	10%	$15 million
Natural gas pipes	$8 billion	1%	$80 million
Bridge decks	$2-3 billion	2%	$50 million
Marina decks	$3.4 billion	5%	$170 million
		Total	$515 million

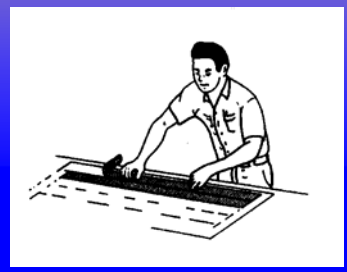
- **According to a report (Stewart, 2002), U.S. FRP composites total 4.2 billion lbs in 2002 (over $24 billion)**
- **A composite manufacturing facility producing 10 million lbs per year is used later in this presentation for cost analysis.**

Technical Solutions

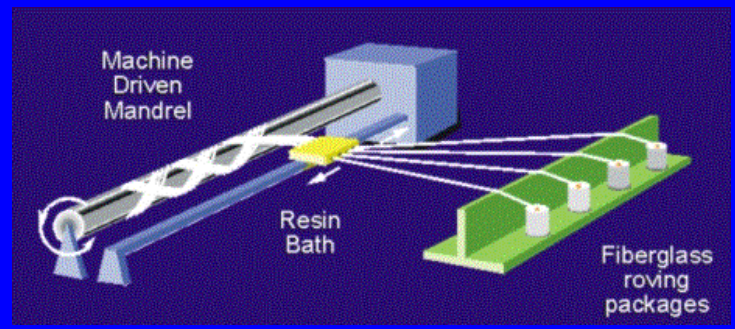
Integration of the state-of-the-art of composites technologies for more durable, lower cost and better performance of FRP products

Manufacturing Methods





- Pultrusion
- Hand lay-up
- Compression molding
- Resin transfer molding/ Resin infusion molding
- Filament winding
- Injection molding



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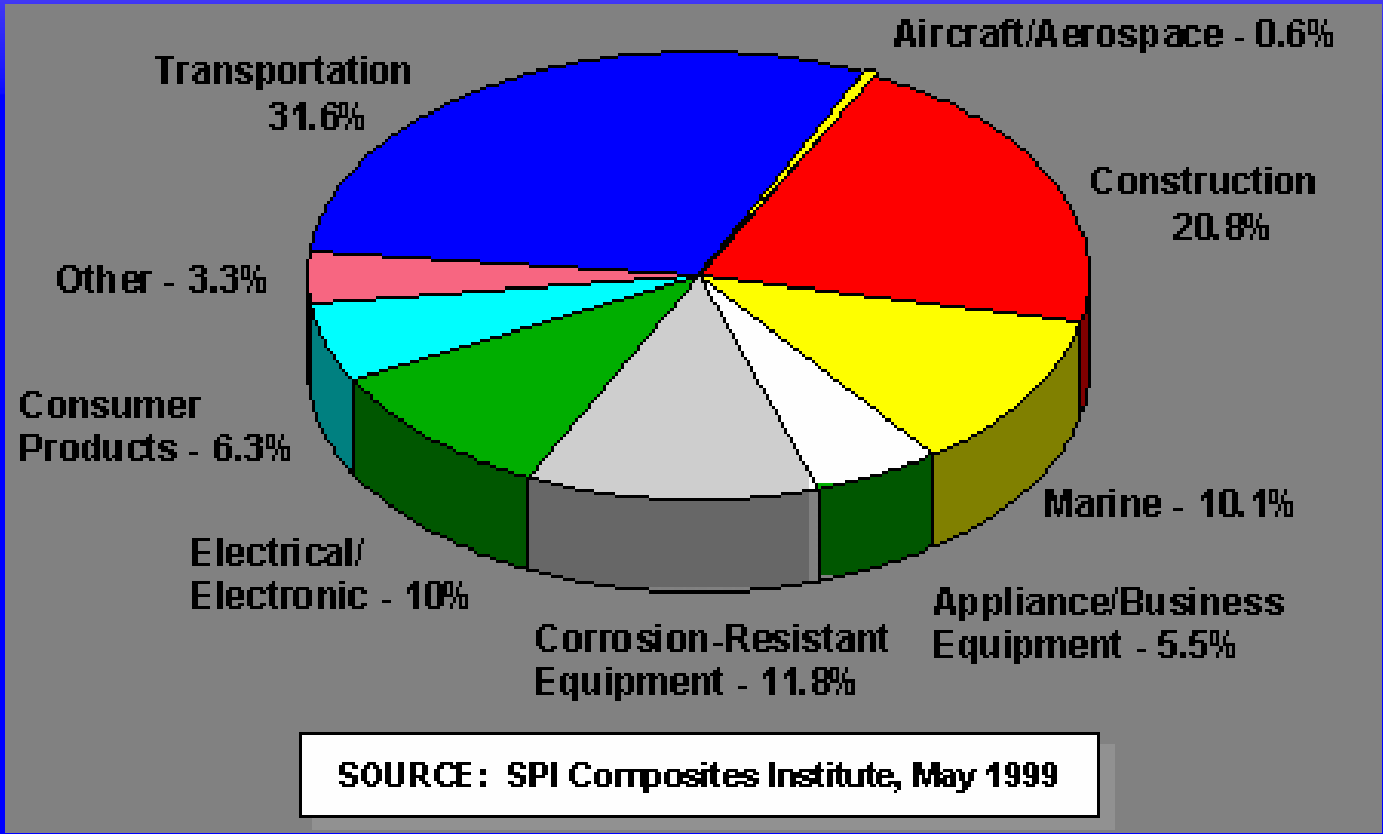
Current Markets and Applications



U.S. FRP composites: 4.2 billion pounds in 2002

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FRP Composites in Highway Structures

- FRP bridge decks
- FRP stringers
- FRP abutment panels
- FRP sign boards and posts
- FRP guardrail system
- FRP sound barriers
- FRP drainage systems (pipes, culverts)
- FRP rebars for concrete bridge decks and pavements

Market Street Bridge, Wheeling, WV – Jointless Bridge

GENERAL INFORMATION

Location: Ohio County, Wheeling, WV
State District Number: 6
Owner: West Virginia Division of Highways
Contractor: JD & E Associates; Wheeling, WV
Date of Construction Completion: July 2001
Superstructure: Steel plate girders
Deck Type: FRP- Creative Pultrusion: Superdeck™

GEOMETRY

Number of Spans: 1
Out-to-Out Length: ~180'
Center-to-Center Bearing Length: 177'
Skew: 0^0
Number of Lanes: 2
Deck Width: 56'
No. of Steel Girders and Spacing: 7 at 8'-6"

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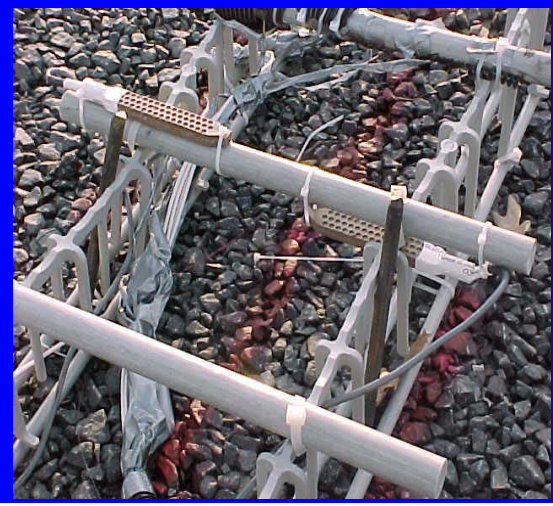
FRP Dowels

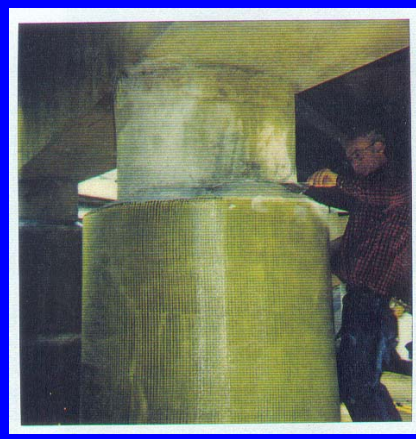
Field installation of FRP dowels at Elkins Corridor H-Project

Close-up of instrumented FRP dowel bars



FRP Wrapping (Wet Lay-up) of Structural Members

Left: GFRP wrapped rail road tie.
Right top: GFRP wrapped guide rail post.
Right bottom: Piers with GFRP wrap, Pond Creek Bridge, Wood County, WV



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Multi-purpose FRP Building

Located in Weston, WV and Constructed with FRP Panels

"The advantages of this building material are its relative lightweight, its ease in handling, and maintenance free" - WVDOT/DOH

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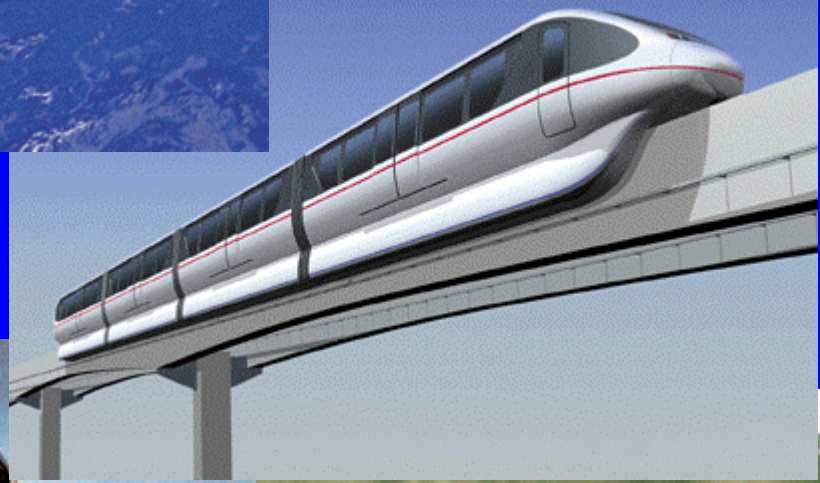
More Applications



Cost Analysis (1)

Proposed composite manufacturing facility (CMF) profile:

- **Products: poles, posts, pipes, panels**
- **~ 10 pultrusion production lines**
- **~ 150 employees**
- **~ 10 million lbs annual sale of composites**

Cost Analysis (2)

Proposed initial investment on *Space and Equipment*:

Item	Description	Unit price	Estimated cost
Land	15 acres		$1,000,000
Floor space	100,000 sq ft	$65 /sq ft	$6,500,000
Machinery	10 pultrusion lines	$150,000 /line (avg)	$1,500,000
Other equipment-	Tooling equipment		$500,000
-Molds	Production molds		$500,000
-Tools, crane, forklift			$200,000
-Q/C testing equip.	Instron, DSC…		$200,000
-Office equipment	Computers, desks…		$100,000
		Total	$10,500,000

Cost Analysis (3)

Proposed operational cost for the proposed CMF:

Item	Description	Unit price	Estimated cost /year
Personnel salary	100 workers	$12 /hr (avg.)	$2,340,000
	40 workers	$15 /hr (avg.)	$1,170,000
	10 management team	$27.5 /hr (avg.)	$536,000
Employee fringe	150 workers	25%	$1,012,000
Utility	Electricity, water, gas	$15,000 /month	$180,000
Materials – Resin	3,000,000 lbs	$1.1 /lb (avg.)	$3,300,000
- Fiber/ Fabric	7,000,000 lbs	$1.5 /lb (avg.)	$10,500,000
Marketing	Sales, development		$200,000
		Sub-total	$19,238,000
F & A		37.5% (avg.)	$7,214,000
		Total	$26,452,000

Cost Analysis (4)

Proposed sales revenue for the proposed CMF:

Item	Description	Unit price	Estimated return /year
Composite sales	2,000,000 lbs	$2 /lb	$4,000,000
	2,000,000 lbs	$3 /lb	$6,000,000
	3,000,000 lbs	$4 /lb	$12.000,000
	3,000,000 lbs	$5 /lb	$15,000,000
		Total	$37,000,000
			(in 3-4 years)

Cost Analysis (5)

Other factors to be considered:

- Depreciation of equipment and plant
- Cash-flows
- Cash accruals
- Interest on loans
- Break-even point
- Contingencies
- Taxes

Financial Outlay

A detailed financial outlay report will be provided upon request, including:

- financial plan for fixed & working capital
- break-even point analysis
- interest computations, etc.

In addition, other items to be provided for evaluation are:

- company contributions
- loans from banks for plant & machinery
- working capital loans
- loans & grants from State / federal agencies
- projected product cost
- profitability analysis

Commercialization Strategies

- **Objective:**
  - Near term goal is to mass produce high volume and high quality structural composite components and systems at competitive prices.
  - Long term goal is to expand into mass production, sales, marketing, and distribution of other products currently or conventionally made of commodity materials like concrete.
- **Dual-use applications**
  - To meet government /public works needs
  - To meet civilian /military needs
- **Phases in commercialization process:**
  - Technology base development (ready from CFC)
  - Product development & demonstration (partially ready)
  - Early commercialization
  - Full commercialization
- **Partnership roles**

Potential Partners

- Constructed Facilities Center – West Virginia University
- Bedford Reinforced Plastics, Inc., Bedford, PA
- ManTech Advanced Systems International, Inc.
- FMW Composite Systems, Bridgeport, WV
- RCBI Composites Technology Center, Bridgeport, WV
- MFG Research Company, Ashtabula, OH

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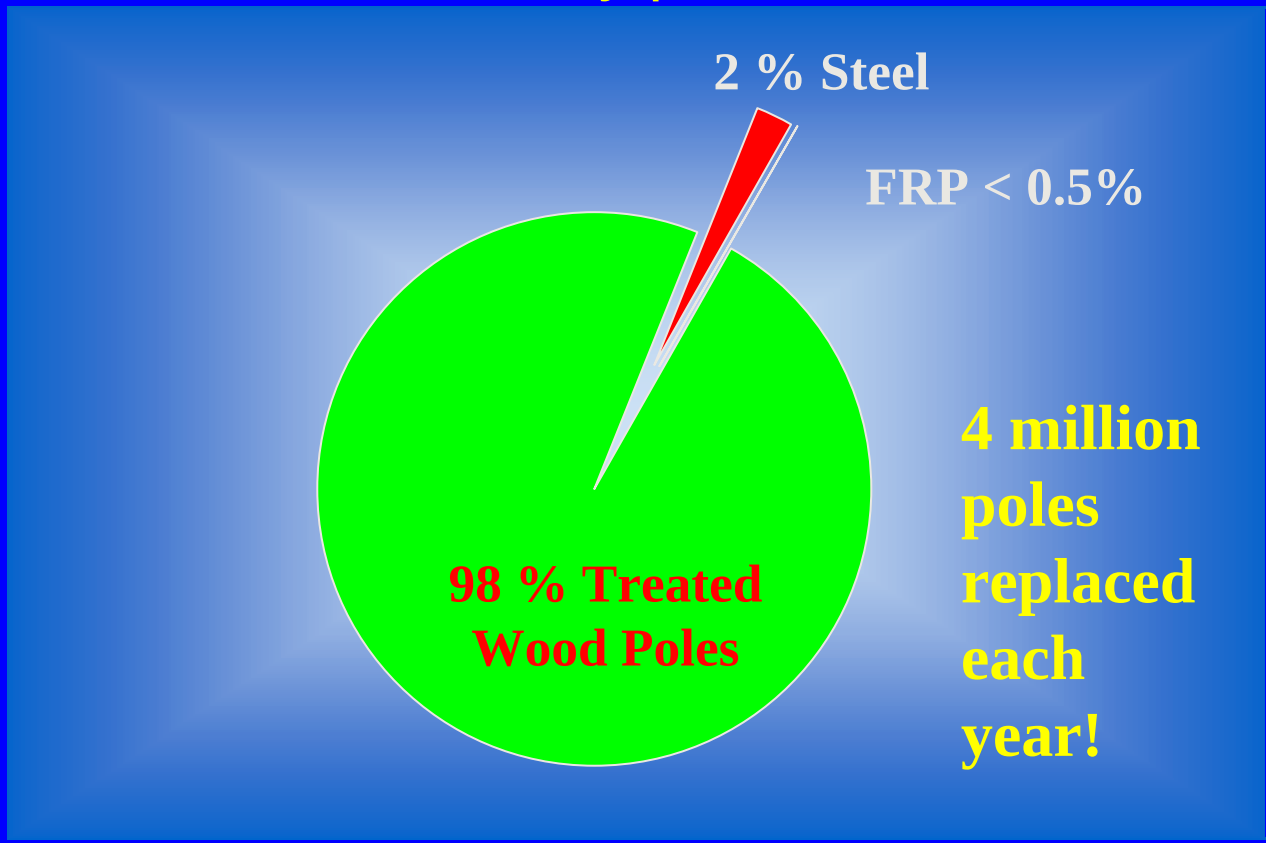
Case Study: FRP Utility Poles

Market of Utility Poles

130 million utility poles in service



What's Wrong With Treated Wood Poles?

- Treated and retreated regularly with Toxic Chemicals
- Environmental concerns also regarding disposal
- Long and straight difficult to obtain (40 – 80 ft)
- Short life expectancy (35years)
- Utility poles – a unsolved highway safety issue

Dollars & Sense: Existing FRP Pole

40 ft Class 4 FRP Pole

- Weighs ≈ 415 - 360 lbs
- Costs ≈ $ 900
- Life Expectancy ≈ 80 years

40 ft Class 1 FRP Pole

- Weighs ≈ 600 lbs
- Costs ≈ $? (est. $ 1500)
- Life Expectancy ≈ 80 years

80 ft Class 1 FRP Pole

- Weighs ≈ 1350 lbs
- Costs ≈ $ 4000
- Life Expectancy ≈ 80 years

1st Generation FRP Pole Data from

- Shakespeare
- Strongwell Ebert

Dollars & Sense: Our Target

40 ft Class 4 FRP Pole

- Weighs ≈ 200 - 225 lbs
- Costs ≈ $ 450 - 500
- Life Expectancy ≈ 100 years

40 ft Class 1 FRP Pole

- Weighs ≈ 250 - 300 lbs
- Costs ≈ $ 650 - 700
- Life Expectancy ≈ 100 years

2nd Generation FRP Pole

- Cost effective
- Higher strength-to-weight ratio
- Better ductility and durability
- Safer

80 ft Class 1 FRP Pole

- Weighs ≈ 800 - 900 lbs
- Costs ≈ $ 2500 - 3000
- Life Expectancy ≈ 100 years

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Summary

- **FRP composites – the materials of 21st century**
  - Market acceptance
  - Advances in FRP composites
- **Time to act for a composite manufacturing facility**
  - Profitability
  - Durability
  - Flexibility
  - Maintainability