Composite Crossarm & Pole Design Update

Industry Standards, Performance & Applications

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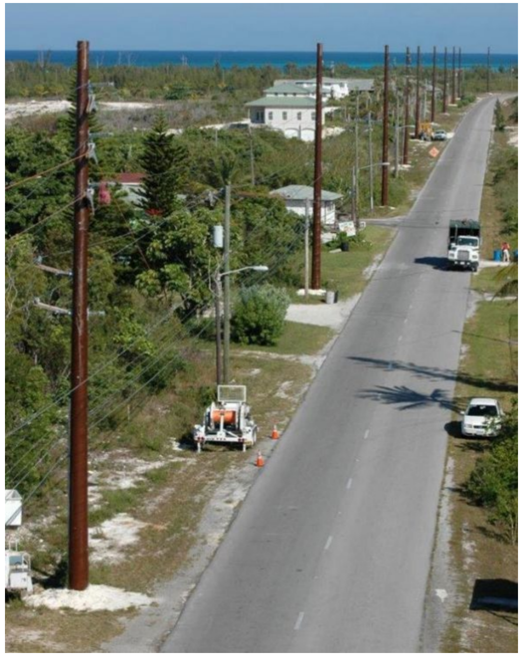
Composites

AN INFINITE WORLD OF POSSIBILITIES

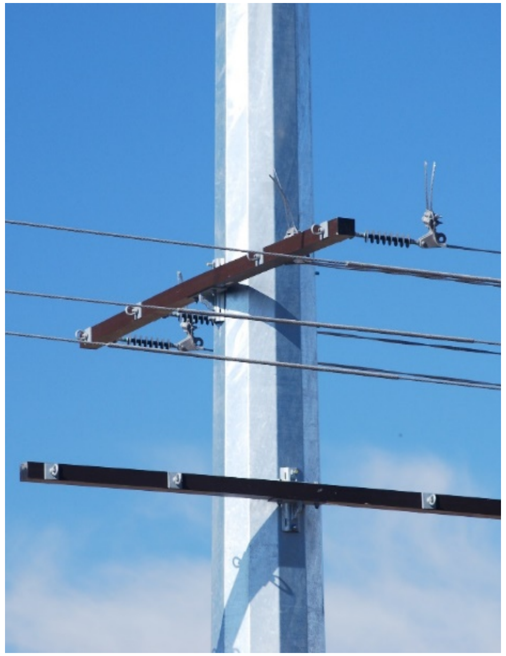
- **Materials of Construction**
- **Typical Applications**
- **Why Composite Poles and Crossarms**
- **Codes and Specifications**

FRP Poles, Crossarms and Line Components

FRP has been used in utility structure applications since the 1950’s when the first FRP poles were installed in Hawaii.

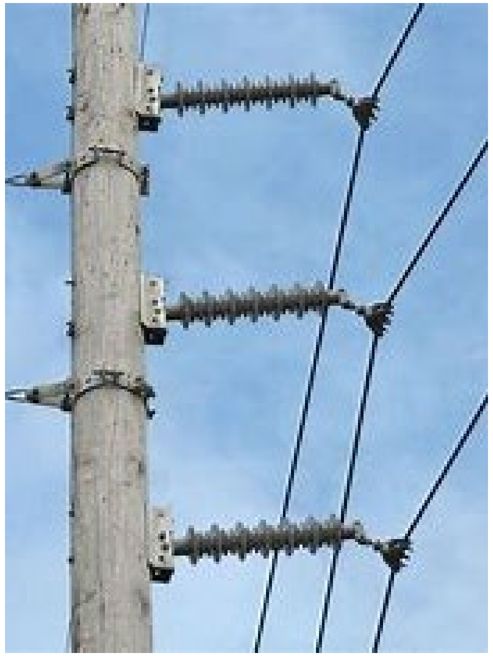


1950’s Composite Poles Introduced



1990’s – FRP Crossarms Deadend and Tangent Introduced

2003 – FRP Transmission H-Frames up to 345kV Introduced



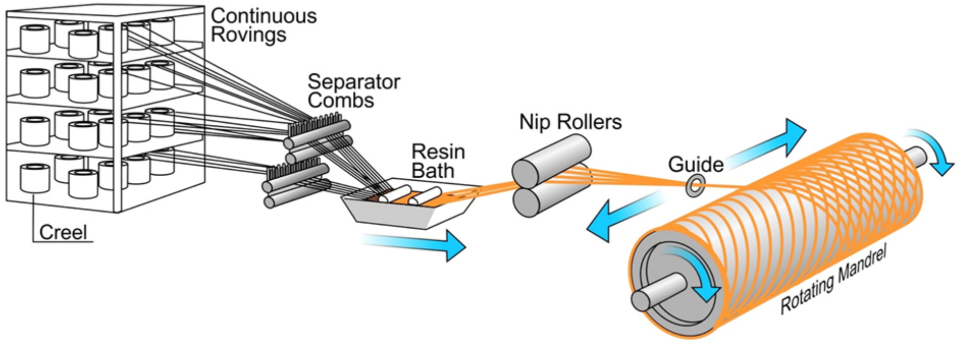
Pre 1980’s – Composite Line Hardware, Tools and Equipment Introduced

Typical Manufacturing Process and Constituent Materials

As a combination of different insoluble constituent materials, composite material properties are orthotropic, and can be engineered to meet specific performance requirements.

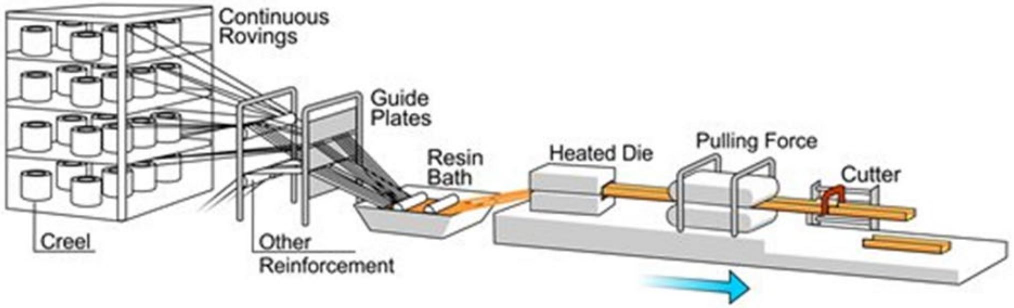
Filament Winding

- Commonly used for utility Poles
- Continuous glass fibers (rovings) impregnated with resin and wound on a mandrel
- Round cross-section; Capable of taper



Pultruded

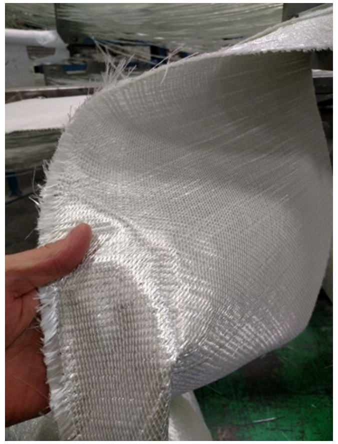
- Commonly used for utility Poles and Crossarms
- Continuous glass fibers (rovings) impregnated with resin and pulled through heated tooling
- Reinforcing mats can be added for additional strength
- Constant cross-section (round or polygonal)



Typical Manufacturing Process and Constituent Materials

FRP Structures – Engineered to Specific Performance Requirements

Unidirectional Continuous E-Glass Roving



Reinforcement Mat

Surface Veil

Typical Constituent Elements of Glass Fiber Reinforced Polymer (GFRP) Utility Structures

- **Rovings –** Electrical Grade (E-Glass)
- **Resin Systems –** Polyester, Urethanes, Vinyl Ester, Epoxies
- **Reinforcement mats –** Mat Provides Off-Axis Strength
- **Surface Veil –** Surface Enhancement & Improved Weathering

FRP Structure Advantages vs. Wood, Steel Concrete

Aged FRP Crossarm

Aged Wood Crossarm

- **Strength** – FRP > 10x stronger (100 ksi tensile vs. 7.5 ksi tensile (wood)
- **Weight** – FRP profiles are hollow & 2-10x Lighter than Wood, Steel or Concrete
- **Electrical Performance and Safety** – Superior Dielectric Strength Increases Worker and Public Safety
- **(Long Lasting) Durability** - Impervious to Water, Wildlife and Decay with Little to No Scheduled Maintenance
- **Environmentally Safe** – Inert Resins Do Not Leach Into Water Systems
- **Reliability and Consistency** – FRP Engineered Structures Provide Predictable Performance

Composite Advantage - Strength

✓ **Composite Utility structures are stronger when compared with wood**

- **Testing (ASTM D8019) conducted on beams for comparative performance**
  - Entry Level FRP crossarm (RUS pattern, wood “equivalent” strength)
  - REA Type-03 Wood Crossarms (New)

Test Specimen	Test Set-Up	Loaded Beams
Composite		
Wood (New)		

Courtesy of GEOTEK, LLC

The strength of FRP composite crossarms relative to wood was observed empirically.

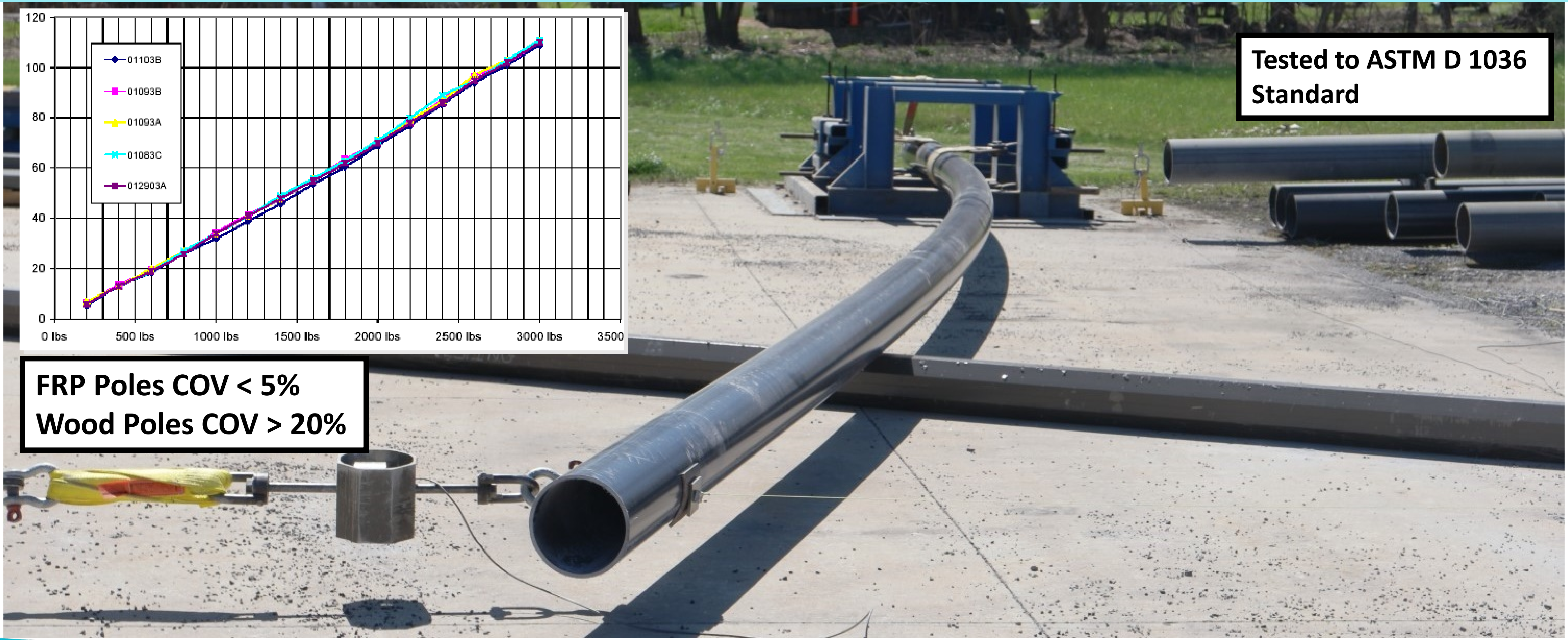
	Ultimate Load (lbs)	
	Wood (New)	Composite
Avg:	3,109	4,436
StDev:	1,264	62
COV:	41%	1%

Courtesy of GEOTEK, LLC

ASTM D8019 Ultimate Load Testing: FRP crossarm with comparable cross-sectional dimensions to wood are available with ultimate load strengths over 16,000lbs (Manufacturer dependent)

Composite Advantage - Consistency

- ✓ **Composite utility structures are more consistent when compared to wood**
- ✓ **ASTM D1036 standardizes ultimate load testing of poles, including FRP**

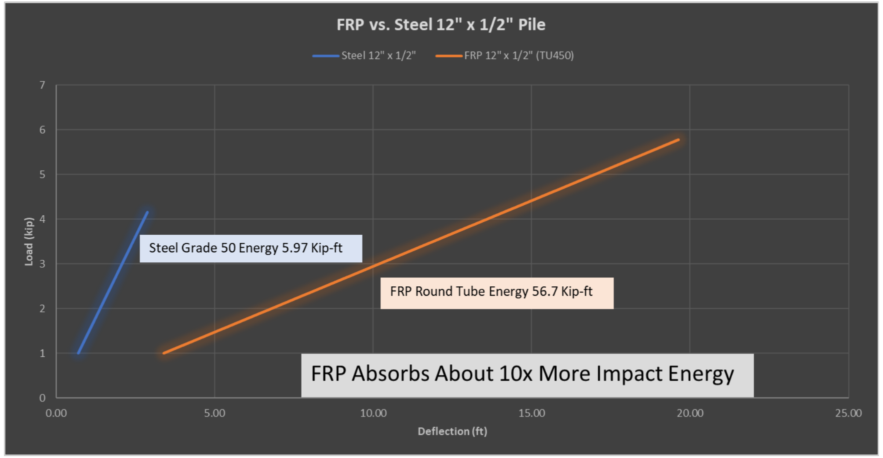


Tested to ASTM D 1036 Standard

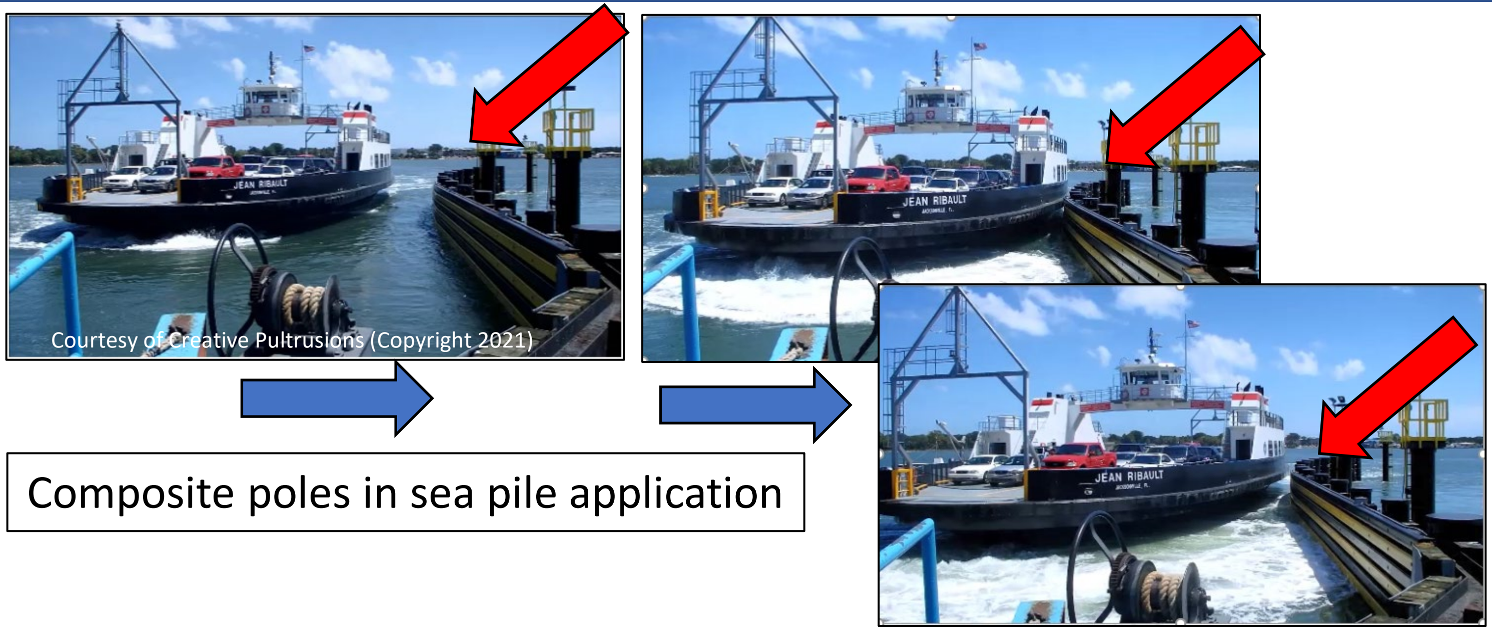
FRP Poles COV < 5%
Wood Poles COV > 20%

Courtesy of Creative Pultrusions

Composite Advantage - Resiliency



Courtesy of Creative Pultrusions (Copyright 2021)

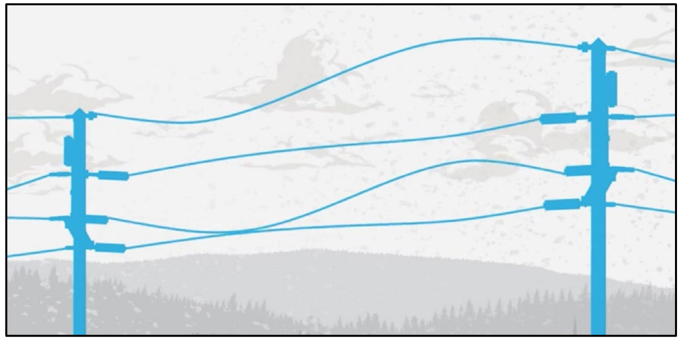


Composite poles in sea pile application

<u>Resiliency</u> – The ability to withstand excessive loading and return to shape or position

<u>Resiliency Benefits to Utility Applications</u>

- Resistance to severe weather
- Unintended impacts (e.g. tree falls on the conductor)
- Ice loading and galloping

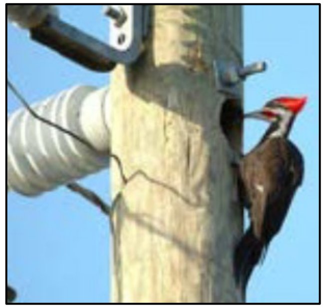


Power Line Galloping

FRP poles and arms absorb excessive energy loads

Composite Advantage - Longevity

FRP Utility Structures - Poles and Crossarms - Service Life 60-80+ years (Manufacture Dependent & Warranties May Apply)



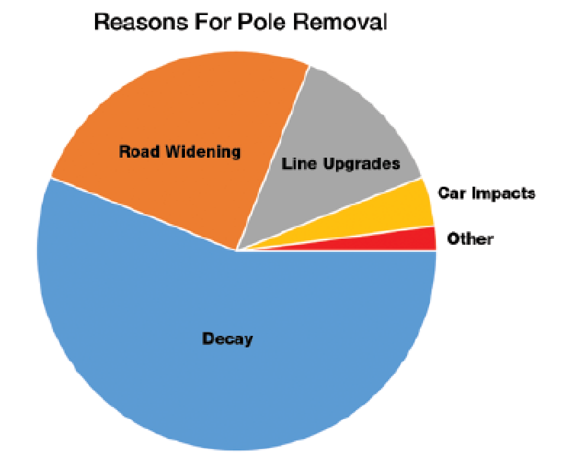


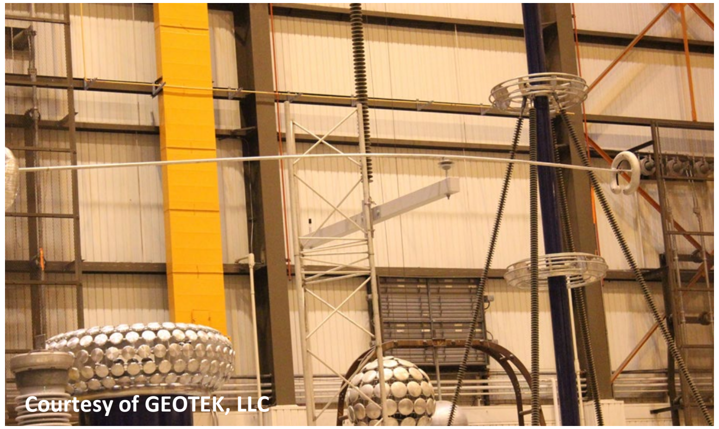
Figure 2 - *While decay was the chief reason for removing a wood pole, the number of poles removed for road widening and line upgrades comprised nearly 38 percent of removals according to a survey of utilities. These poles could be candidates for reuse, which should be factored in when determining the overall service life. (Source: 2007 Utility Pole Research Cooperative Annual Report)*

- **<u>Wood Poles & Crossarms - Decay is Normal</u>**
  - Wood Pole Decay- #1 reason for wood pole removal/replacement (Ref: wood pole council)
  - Wood pole testing required to achieve life expectancy
  - Recently, the EPA has proposed the discontinuation of pentachlorophenol, a common wood pole and crossarm treatment.
- **FRP Structures Are Not Susceptible to Rot, Wood-Pecker/Insect Damage, and Corrosion Which can Reduce the Service Life of a Wood Utility Structure.**
- **FRP Poles and Crossarms Resist Weathering Effects Including UV Degradation**
  - Review individual manufacturers processes & test results such as accelerated UV testing (ASTM G154, Cycle 1)which reveals material performance
  - Field installation observations support testing claims

Composite Advantage in Utility - Electrical Performance

Fiberglass Poles and Crossarms are electrically insulating

- While not rated as an insulator, fiberglass provides addition electrical design margin to improve grid reliability
- Safety during hot line work
- Application: Pole Top Fire Mitigation
  - The smooth outer surface of fiberglass crossarms resist tracking and reduce pole top fires.



Flashover electrical tests of fiberglass crossarm demonstrating electrical insulating properties of FRP (arc is jumping the air gap)


T&DWorld

SEARCH LOG IN

New fiberglass crossarms are smooth and resistant to contamination.

Installing Fiberglass Crossarms

To reduce the risk of pole-top fires, Colorado Springs Utilities reached out to GEOTEK, which makes PUPI fiberglass crossarms and braces. The manufacturer shared the experience of an electrical utility in Alberta, Canada, that had once experienced 80 pole fires in two days. To remedy the situation and to prevent future fires, this utility is in the process of replacing its wood crossarm infrastructure with 10,000 fiberglass ones. So far, the utility has not reported any pole files to the company.

https://www.tdworld.com/field-applications/utility-extinguishes-risk-pole-top-fires

Utility Structures - Resiliency Applications

Courtesy of GEOTEK, LLC

Grid hardening of fire-prone areas

Before in 2012

After Irma 2017

Courtesy of Highland Composites / Intelli-Pole

Grid hardening of hurricane prone areas

Utility Structures – Grid Hardening and Limited Access

Courtesy of RS Poles

Grid Hardening after storm damage

Difficult Access

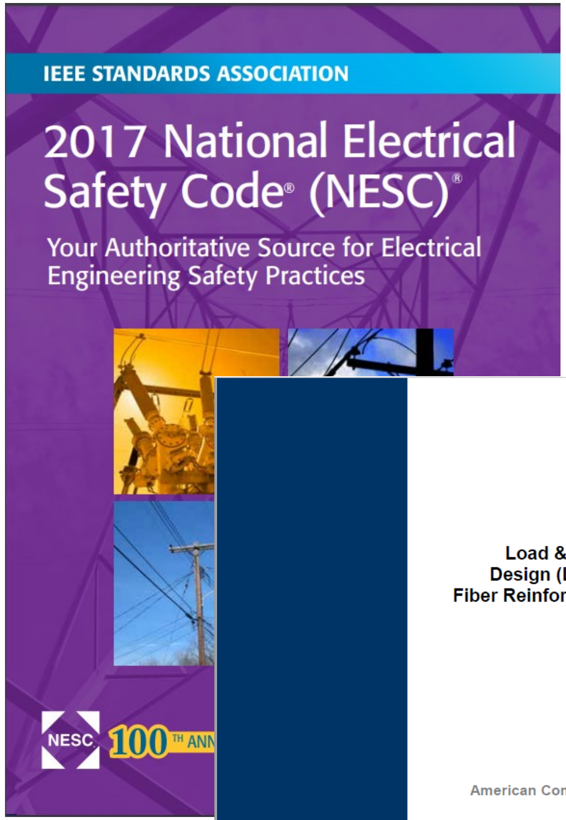
Design Requirements and Safety Codes

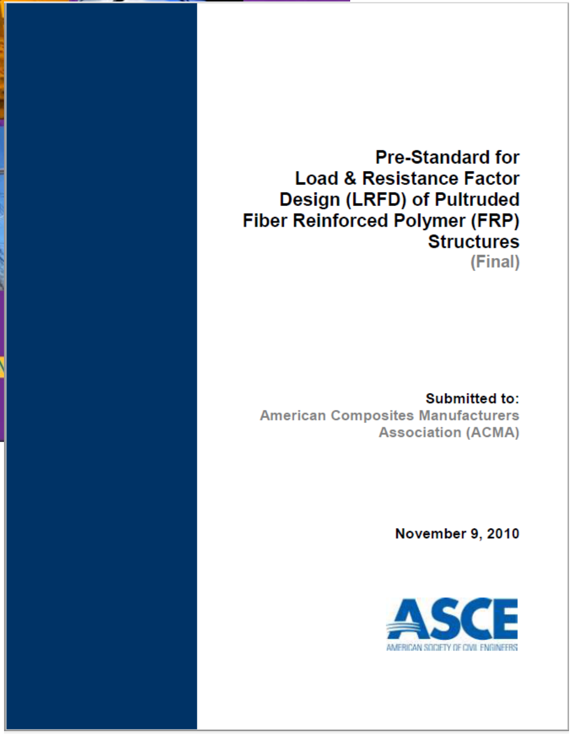
North American utilities use multiple sources of codes, standards, and specification to establish their Utility Structure and Line design practice

- National Electric Safety Code (NESC) -> Includes FRP poles and crossarms. De-rating of FRP material not required when using the 5% LEL ultimate load due to consistency.
- General Order 95 (GO-95) – Used in California.
- Load and Resistance Factor Design (LRFD) – Can be used to develop allowable material load limits, based on various loading and environmental conditions.
- CSA – Canadian Standard Fiber Reinforced Polymer Crossarms
- Past experience, best practices, and internal standards

International customers may consult other international codes and standards for Utility Structure and Line Design

- Euro-COMP – International standard used to develop allowable material load limits, based on various loading and environmental conditions.




Pre-Standard for
Load & Resistance Factor
Design (LRFD) of Pultruded
Fiber Reinforced Polymer (FRP)
Structures
(Final)

Submitted to:
American Composites Manufacturers
Association (ACMA)

November 9, 2010

ASCE

Test Standards And Specifications

- ACMA Standard Specification for FRP Composite Utility Poles 1st Edition (ANSI Approved)
- ASTM D8019 – Establishes a standard to test FRP crossarms for ultimate load and deflection performance
- ASTM G154 – Test standard for accelerated outdoor weathering testing of non-metallic materials
- ASTM D1036 – Pole strength standard
- ASTM F711 and IEEE 978 Electrical testing
- ASCE Manual of Practice 104 *Recommended Practice for Fiber-Reinforced Polymer Products for Overhead Utility Line Structures*
- ASCE EP111 – *Reliability Based Design of Utility Pole Structures*

INTERNATIONAL

Designation: D8019 – 15

Standard Test Methods for Determining the Full Section Flexural Modulus and Bending Strength of Fiber Reinforced Polymer Crossarms Assembled with Center Mount Brackets[1]

This standard is issued under the fixed designation D8019; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods cover the determination of the flexural modulus and bending strength of both tangent and deadend arms bent about their minor and major axes. One method covers testing of assembled tangent crossarms including the tangent bracket and relative hardware. The other method covers testing of assembled deadend crossarms with a deadend bracket and relative phase loading hardware. The failure modes and associated stresses can be used for predicting the phase load capacities of pultruded crossarms specific to certain conductor loading scenarios.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no known ISO equivalent to this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D4968 Guide for Annual Review of Test Methods and Specifications for Plastics

Take Aways and Key Points

- FRP poles and crossarms are engineered products which exhibit high strength and low coefficient of variation compared to legacy pole and crossarm materials such as wood.
- Standardized testing of FRP poles and crossarms allow development of reliable and comparable material properties and performance.
- FRP utility structures are inherently resilient in that the FRP materials exhibit high bending strength with a moderate modulus of elasticity, meaning FRP materials having the ability to absorb significant energy during high winds and impacts.
- FRP materials are long lasting and well suited for the outdoor service environment, require minimal maintenance, and will not rot, decay, or corrode.
- Fiberglass FRP materials are inherently electrically insulating, promoting grid reliability.
- FRP materials are inert and will not leach chemicals into the environment.

QUESTIONS?

Thank You!

ACMA Composites Technology Day