GOODWINDS COMPOSITES

OPTIMIZING INDUSTRIAL APPLICATIONS WITH COMPOSITE RODS & TUBES

Build lighter, stronger products
without adding cost or time

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Design and manufacturing engineers are under constant pressure to cut weight, hold tight tolerances, and extend service life without adding extra cost or lead time. Using metal or other structural materials can be an impediment.

WHAT TO DO?

If you’re building robots, automated systems, drones, vehicles, heavy equipment, or durable consumer products, advanced composites deserve a closer look.

This guide provides practical advice on when and why composites are superior to metals or other structural materials, evaluating composite materials, and accurately specifying carbon rods and tubes for reliable, repeatable results.

ENGINEERING CHALLENGES IN MODERN MANUFACTURING

Several constraints set a ceiling on cycle time, reliability, and total cost. However, the right composites strategy can turn bottlenecks into advantages:

Weight vs. Strength

Carbon and fiberglass composites can match metal-like mechanical performance at a fraction of the weight when layup and fiber orientation are matched to the load path. The tradeoff depends on whether the design is limited by weight or by geometry:

- **For a given weight**, carbon fiber profiles generally provide higher stiffness-to-weight and strength-to-weight than aluminum or steel, enabling lighter structures, smaller actuators, and faster motion. Carbon's density is typically ~1.6–1.9 g/cc (vs. fiberglass ~2.5 g/cc, aluminum ~2.7 g/cc, and steel ~7.8 g/cc)

- **For a given volume**, metals such as steel can be stiffer in absolute terms. For example, a steel rod or tube with the same OD/ID and length as a carbon rod or tube will usually be significantly stiffer, but also much heavier

Fatigue & Vibration

Where cyclic loads and resonance shorten metal life, carbon shows excellent fatigue resistance; fiberglass absorbs impact energy and is less brittle than metal — a useful combination for mechanisms that cycle millions of times or experience shock loads.

Tolerances & Straightness

With composites, precision can be designed in from the start. Define requirements for OD, ID, wall thickness, cut length, straightness, and how the part must fit with mating components, then select the manufacturing method that best supports them:

- Pultrusion's unidirectional architecture and highly automated, repeatable production support tight tolerance profiles at volume

- Roll wrapping adds fiber-orientation control for complex geometry without giving up consistency

Harsh Environments

Composites inherently resist moisture and many chemicals. Fiberglass is preferred near saltwater or anywhere galvanic corrosion with metals is a risk. Resin choice sets the baseline UV resistance; finishes and coatings can raise it to match the duty cycle.

Electrical & Thermal Requirements

Composites provide flexibility in choosing the needed behavior:

- Carbon offers low thermal expansion and electrical/thermal conductivity for dimensionally stable, grounded structures
- Fiberglass is electrically insulating with a higher Coefficient of Thermal Expansion (CTE), making it ideal around high voltage or Radio Frequency (RF)-sensitive systems

Time-to-Market & Cost

Composites help engineers move faster with lower tooling costs than comparable metal work. Process fit lets you match market timing and economics to scale:

- Pultrusion is cost-effective and high-volume
- Roll wrapping excels for custom layups, small/medium runs, and multi-directional strength

WHY COMPOSITES OUTPERFORM METALS AND OTHER MATERIALS

Composites exceed metals and other materials in the properties that matter most in real-world applications.

Key Mechanical Advantages

- **Strength-to-weight & stiffness-to-weight:** Carbon delivers outstanding stiffness and strength per unit weight; fiberglass provides strong, resilient performance with better impact tolerance. As a result, weight is reduced without sacrificing structural integrity
- **Fatigue performance:** Carbon's fatigue resistance is excellent in cyclic service; fiberglass is moderate but excels in impact absorption

Design Flexibility Through Fiber Orientation

Since fibers can be oriented where loads occur, axial stiffness and strength can be tuned in bending or in torsion. Isotropic metals simply can't match this design flexibility without adding weight and usually cost.

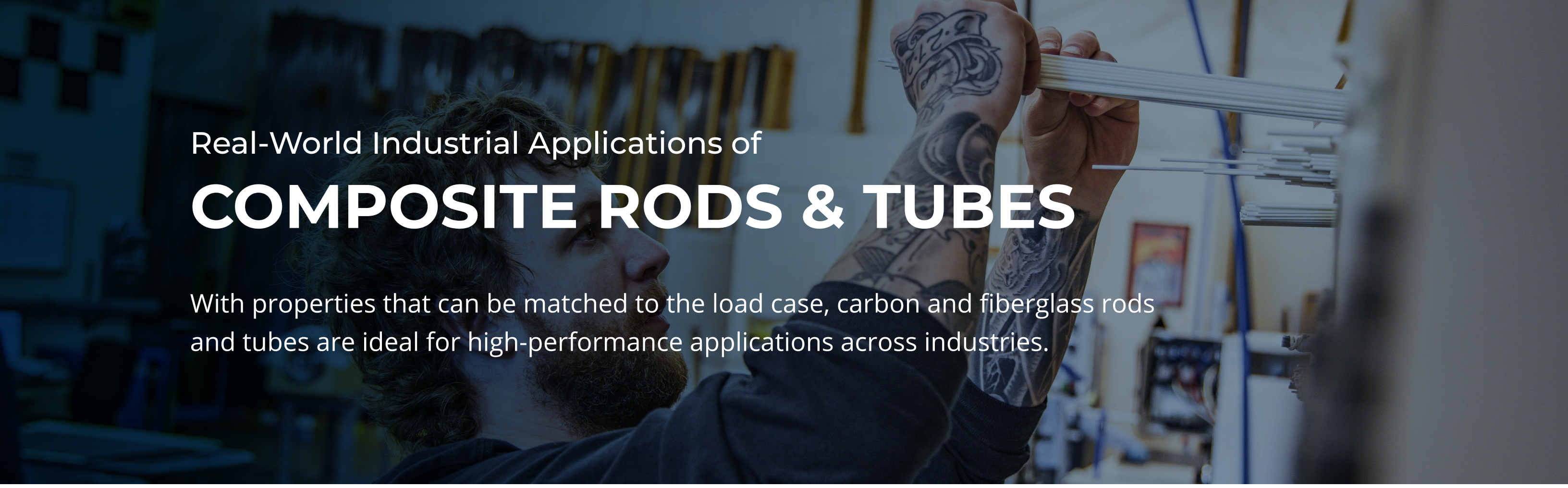
Environmental and Functional Benefits

- **Corrosion resistance:** Both carbon and fiberglass resist moisture and many chemicals; fiberglass is often preferred around saltwater or where galvanic corrosion with metals could occur
- **Thermal & electrical behavior:** Carbon has low CTE and is conductive. Fiberglass has a higher CTE and is insulating — ideal for applications exposed to high voltage, or sensitive electronics

Key Properties of
STRUCTURAL MATERIALS

KEY PROPERTIES OF STRUCTURAL MATERIALS

MATERIAL	DENSITY	STIFFNESS TO WEIGHT	STRENGTH TO STIFFNESS	CORROSION RESISTANCE	ELECTRICAL BEHAVIOR	THERMAL EXPANSION
Carbon fiber composite	Very low (vs. metals)	Outstanding	Excellent	Excellent	Conductive	Very low (axial)
Fiberglass composite	Low (vs. metals)	Moderate	Good	Excellent	Non-Conductive	Moderate
Aluminum	Moderate	Moderate	Moderate	Good (can pit/oxidize)	Conductive	Moderate to High
Steel	High	Low (per weight)	Low (per weight)	Fair (rusts without protection)	Conductive	Moderate



Real-World Industrial Applications of

COMPOSITE RODS & TUBES

With properties that can be matched to the load case, carbon and fiberglass rods and tubes are ideal for high-performance applications across industries.

Robotics & Automation

- **End of Arm Tooling (EOAT) and pick-and-place linkages:** Lower inertia means faster cycles and smaller actuators
- **Idler/drive rollers:** Corrosion-resistant, dimensionally stable, and lighter to spin up
- **Safety and guarding components:** Fiberglass is used where electrical insulation is required

Aerospace & UAV

- **Booms, struts, frames:** High stiffness-to-weight and excellent fatigue performance
- **Antenna masts:** Carbon for stability; fiberglass for RF transparency and insulation

Automotive & Mobility

- **Linkages and brackets exposed to harsh environments and substances:** Corrosion resistance with predictable stiffness
- **Interior structures and seat components:** Weight reduction without compromising strength

Heavy Equipment & Industrial

- **Structural supports and standoffs:** Corrosion-resistant performance near chemicals or outdoor exposure
- **Live-line tools and extensions:** Fiberglass provides electrical insulation for high-voltage maintenance

Consumer/Medical/Instrumentation

- **Telescoping tubes and poles:** Lighter, stiffer, and easier to handle
- **Micromechanisms and medical devices:** Micropultruded rods (0.5–3.0 mm) for compact, precise assemblies

Process Decision

MATRIX

PROCESS	BEST FOR	TYPICAL ADVANTAGES	COMMON USE CASES
Pultruded rod/tube	Axial tension/ compression; straightness	High volume, tight repeatability, cost effectiveness	Linear applications, struts, push-pull rods
Roll-wrapped tube	Torsion/multi-directional loads; complex shapes	Tunable layups, strong in torsion, small/medium runs	Drive shafts, boom arms, custom ID/OD
Micropultrusion	Sub-3mm diameters	Very small, precise profiles for compact designs	Medical devices, aerospace components, fiber-optic supports, mini-mechanisms

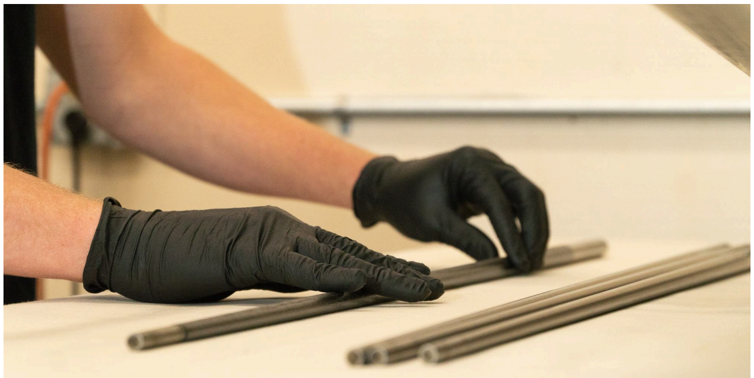
How Goodwinds Composites

MANUFACTURES RODS & TUBES TO SPEC

Goodwinds Composites uses two complementary manufacturing approaches for composite rods and tubes. Identifying the right process early keeps costs aligned with performance targets.

Pultrusion (repeatable, axial performance)

Continuous fibers are drawn through resin and a heated die that defines the profile. The result is a unidirectional, highly automated, cost-effective part with excellent tensile and compressive properties along the length. Pultrusion is ideal for straightness and high-volume production where axial loads dominate.



Roll Wrapping (tailored, multi-directional strength)

Carbon fiber or fiberglass fabrics pre-impregnated with resin (prepregs) are wrapped over a mandrel (which sets the ID/shape), and layered to orient fibers precisely for torsion and crush resistance. Once compacted and cured, roll wrapped tubes provide exceptional design flexibility, shape customization, and strength in multiple directions.

What is Micropultrusion?

Micropultrusion uses the same principles and materials as pultrusion, only on a smaller scale. It is used to produce very small composite rods that range anywhere from 0.5mm to 3.0mm in diameter.

These minute rods are often used in medical devices, aerospace components, fiber optic supports, fabric reinforcement, and miniaturized mechanical assemblies.

What Affects Composite Rod Flexibility?

1. **Material:** Fiberglass deflects nearly twice as much as carbon at the same length and diameter
2. **Length:** Longer rods bend more
3. **Diameter:** Small increases in diameter dramatically reduce deflection (e.g., 6.35mm vs. 4.76mm)

ENGINEERING DESIGN CHECKLIST

Define the essentials early so geometry, materials, and process stay aligned with the load case.

Geometry & Tolerances

Specify:

- [ ] OD/ID
- [ ] Wall
- [ ] Length
- [ ] Straightness
- [ ] Tolerance expectations

Materials

Choose:

- [ ] Fiber (carbon for stiffness/weight and conductivity; fiberglass for insulation/impact)
- [ ] Resin
- [ ] Finish (smooth or sanded)

Load Cases

Determine:

- [ ] Pultruded for axial tension/compression
- [ ] Roll-wrapped for multi-directional and torsional loads

Secondary Operations

Plan:

- [ ] Bonding/painting surfaces
- [ ] Cut and finish requirements (lengths, diameters, tolerances)
- [ ] Machined features and locations (holes, slots, notches)
- [ ] End and edge preparation (chamfers, tapers, sanding)

Partnering with Goodwinds Composites:

FAST, PRECISE, ACCOUNTABLE

Goodwinds Composites invests in partnerships, not transactions. Work directly with a responsive, experienced engineering team that takes a collaborative approach to concepting, material selection, development, prototyping, and manufacturing to your specs.

Engineers value a Goodwinds Composites partnership because our promises are unparalleled and our benefits are proven:

- **Dedication to Excellence:** Every part is double- and triple-checked to meet exacting standards so you get top-quality products the first time, every time

- **Made in the U.S.A.:** Domestic sourcing and manufacturing shorten lead times and streamline communication

- **Experienced, Capable Team:** From small runs to large-scale builds, our engineers and machining specialists handle projects of any complexity

- **Strategic Location:** Based in Washington's Skagit Valley — a hub for machining, aerospace, and marine tech — we network with nearby innovators to help out and also stay on top of industry trends

Goodwinds Composites is ready to help you optimize industrial applications with composite rods and tubes. Bring us your toughest challenge! Reach out to our engineers to discuss your next project and the solutions we offer.

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