Polymer Composite Utility Poles Offer Grid Resilience to Wildfires

Wildfires are a serious threat to local electric grid infrastructure. A key part of this infrastructure is the utility pole. Steel and timber poles are ubiquitous, but both can crumble in minutes under the onslaught of a roaring wildfire. Steel fails when the temperature exceeds 1,400°F and timber poles collapse if they lose even a fraction of an inch of their diameter during a fire. In California alone, wildfires have claimed tens of thousands of structures, costing close to $14 billion in direct damage and $100 billion in environmental cleanup and power grid infrastructure repair in 2020.

The acute need for stronger and fire-resistant utility poles is now being met by fiber-reinforced polymer (FRP) composite poles. FRP tall poles (100 ft or more) have received attention from utility companies due to their lower cost and superior fire resistance than steel, timber, and concrete. On a high-volume basis, a 16-in.-dia., 100-ft FRP pole costs a third to half the installed cost of a typical 15-ton steel lattice (flat) structure. FRPs are made of two or more constituents, such as glass fibers bonded with polymers, resulting in better thermomechanical responses than glass and polymer alone.

▲ Wildfires can compromise traditional steel and timber utility poles. Researchers are developing fiber-reinforced polymer (FRP) composite poles that are more resistant to wildfires.

A wildfire involves a dynamic sequence of events involving a range of elevated temperatures (up to 400°C and even 800°C for very short durations), high heat fluxes (up to 100 kW/m^2), and exposure times (up to 2 min). These factors combine to impact the mechanical and durability properties of FRP utility poles. But systematic testing and evaluation of these properties is challenging, and no such study existed on FRP composite utility pole response to wildfires.

The Center for Integration of Composites into Infrastructure (CICI), an Industry-University Cooperative Research Center funded by the National Science Foundation (NSF), is studying FRP pole performance and improving pole designs to enhance the fire resilience of the electric grid.

The CICI site at West Virginia Univ. has developed accelerated testing methodologies and evaluation metrics to assess FRP utility pole performance characteristics, including strength and stiffness, ductility and durability, wind-driven bending fatigue, and cost. Researchers led by Professor Hota GangaRao have developed better design and manufacturing strategies (*e.g.,* curing, fiber layout and wet out, low void content, and intumescent coatings and shields) that enhance the fire performance of FRP poles to provide at least 60–70 years of service without any maintenance. The knowledge gained has catalyzed research to develop even higher performance FRP utility poles.

FRP utility poles are designed with glass-fabric layers — *e.g.,* approximately 40 layers of fabric per 0.5-in. wall thickness — that form a protective barrier around the inner resin and fire-retardant matrix. This design slows the fire-front progression and delays ignition enough to prevent poles from failing in wildfires of short durations.

CICI researchers found that FRP poles experience approximately 25% loss of strength at high temperatures due to short durations (<30 sec) of moderate fire exposure (peak temperatures of around 400°C), during which one outer glass fabric layer burns off. Under severe fire conditions (exposures around 2 min, peak temperatures of 800°C), FRP poles burn off one layer of glass fabric per minute. After several more minutes of severe fire exposure, the FRP poles fail. The team has identified ways to enhance fire performance under severe fires with better resin formulations, innovative fiber usage, and fire-retardant cores, shields, and coatings.

Further research has shown that the FRP pole retains up to 75% of its thermomechanical performance after moderate fire exposure (exposures of around 30 sec, peak temperatures of around 400°C), withstands twice as high the failure stress of steel, and can be repaired and restored to regain their strength and structural integrity using composite wraps.

"The work done at CICI has been critical in studying and quantifying the superiority of fiber-reinforced composite poles over traditional materials such as wood, steel, and concrete," said Shane Weyant, CEO of Creative Composites Group, a member of CICI. He adds, "It is easy to see why composite poles are gaining significant market share in infrastructure and corrosion-related markets as the material of choice." CEP

This technology was funded through the NSF Industry-University Cooperative Research Centers (IUCRC) Program.

This article was prepared by the National Science Foundation in partnership with *CEP*.