Global Trends in Carbon Fiber Technologies in Building and Construction

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Carbon Fiber and its derivatives are used in limited cases today on existing infrastructure repairs.

Carbon Fiber solutions reduce structural risks
- Aging (steel corrosion, stress cracks)
- Increased use (e.g., heavier loads)
- Seismic activity

Carbon Fiber solutions value over incumbents (replacement, steel plates) is based on:
- Strength/stiffness (CF to bear load without tensioning or further material deflection),
- Ease of installation,
- Resistance to fatigue and corrosion,
- Reduced out-of-service time and
- The low portion of Carbon Fiber in total project cost (reducing construction cost)
Why Use CF Composites in Building and Construction Industry?

Light Weight
Composites are roughly half to three-quarters the weight (depending on fiber type) of aluminium and one-quarter the weight of steel. Weight reduction using composites has created a huge market demand, particularly in creating cost efficiencies, longevity and design freedom in the architecture, construction, marine, industrial, energy and automotive industries.

Corrosion Resistant
Composites have a high resistance to water, chemicals and the environment which make them a perfect material choice for outdoor exposure such as yacht structures, architectural facades, turbine blades and civil construction applications. Their inertness means they do not react with other materials.

Low Maintenance/Long Life
Composite structures have an exceedingly long life span and require minimal maintenance due to their durability and resistance to corrosion. Maintenance requirements are significantly lower than wood or metal. The combination of low maintenance and long-life gives composite materials excellent life-cycle costs.

Design Freedom
Composites can be molded into an infinite number of complex shapes. The difference with composites is the ability to engineer into the laminate, specific structural, compliance (eg fire ratings) and aesthetic qualities without compromising the design. With composites the design comes first, engineering analysis on the shape will then deliver the required make up of the composite laminate.

High Strength To Weight Ratios
Carbon fiber composites have the highest strength to weight ratio of any material available today. Composites can have two-and-a-half times the ultimate tensile strength of steel, yet less than a quarter of the weight per unit volume.

Structural Efficiency
The vast range of resin/ reinforcement combinations available and the ability to design and tailor differing strength characteristics within a single form allows the most progressive shapes to be both light and strong.
Key barriers to adoption are design/insurance engineers who bear risk for new solutions. This is also the case for construction repair, though the key decision makers are more fragmented.

**Key groups to influence:**
1) Government and associations who approve Carbon Fiber applications
2) Design and insurance engineers, risk adverse and unfamiliar with Carbon Fiber
3) University engineers writing standards, developing new uses and educating
Carbon Fibers in precast concrete started to appear in USA from early 2000s. A carbon fiber grid is used in the panel faces to replace steel mesh reinforcement, and as a mechanical link to the outer and inner sections of the concrete walls (Figure1).

- Non-corrosive carbon fiber grid reinforcement in the wall panel face allows less use of concrete, which reduces weight and raw material usage.
- The wall panels with carbon fiber grid reinforcement can weigh about 40% less than conventional precast panels.
- Carbon fiber is used as a shear grid or shear truss to connect the inner and outer concrete surface of sandwich wall panels, creating a fully structurally composite, thermally efficient unit.

Carbon Fiber grid is integrated as reinforcing in the double tee slab to replace conventional steel mesh (Figure2). Replacing welded grid with carbon fiber grid in the slabs reduces weight and the need for chemical protection.
Main reasons to use carbon fiber in precast concrete:

- **Non-corrosiveness**: Because carbon fiber will not oxidize, it will not cause rusting, staining or spalling as can occur with steel reinforcing. Consequently, precasters can reduce the amount of concrete cover—three inches or more in the case of some wall panels—that would have been required to protect the reinforcement.

- **Weight**: As noted previously, the opportunity to reduce the amount of concrete cover can lead to significant weight reductions: up to 50% in wall panels and up to 8% in double tees. For architects and engineers, reduced weight contributes to cost savings starting with foundations and building superstructure and extending to lower shipping costs and crane expenses.

- **Thermal efficiency**: The use of carbon fiber grid enables improved thermal performance, because carbon fiber composites, which are used in precast production has low thermal conductivity and reduces the transfer of heat or cold from outside to inside. The insulation embedded in the walls can deliver 100 percent of its rated performance without hot spots or cold spots.

- **As a result**, building owners can benefit from **long-term energy savings**.

A carbon fiber grid costs more than twice as much as conventional steel reinforcing. But that is usually more than offset by reductions in concrete and chemical treatments that would have protected the steel, as well as lower HVAC demands and the possibility of reducing the building foundation and substructure. Less concrete means; **less CO2 emissions**.
Giovanni Pagnotta’s Carbon Fiber furniture
I’ve always been motivated by interesting materials, and how they can influence design. As I’ve stated in the past carbon fiber is a super material, and its specific strength to weight ratios allows you to warp the rules of physics – for example, impossibly thin cross sections and super light solutions.

Makkah Clock Tower, at 607m tall the building is the second tallest in the world.

Premier Composites Technologies (Dubai, UAE) built the top 200m of the tower is clad with over 40,000m² of advanced FRP composite panels made by Gurit’s carbon fiber prepregs, including the largest clocks in the world - 43m in diameter, with 23m long minute hands.
Use of Carbon Fiber Rods

- Fatih Sultan Mehmet Bridge uses Carbon Fiber Rods,
- This technology and material is also going to be used in the 3rd Bridge over Istanbul’s Bosphorous.

FiReCo of Norway, has designed and built the 2 x 28 m, in glass and carbon Fiber opening footbridge in Fredrikstad, Norway.

‘The construction was more cost competitive than steel and concrete for this bridge, partly due to reduced size of lifting cylinders, saved time and cost for installation equipment – again an example that cost/kg material is not so interesting when comparing concepts...’
Future of Carbon Fiber In Architecture, Building and Constructions

Fitchburg is the first in the state to benefit from new “bridge in a backpack” technology, a quicker and cheaper alternative to previous bridge construction methods.

Carbon fiber tubes are used as arches in the bridge. The tubes, which are put in place more quickly and with less equipment than typical bridges, are secured in concrete footings.

Corrosion-resistant corrugated decking is placed over the arches and the tubes are then filled with concrete. Concrete is then placed on the decking.

They are 14 meters long and 30 cm in diameter and weigh about 100 kg. There are 15 tubes in the bridge, which spans 12 meters from footing to footing.

The technology was developed by the University of Maine.
Q&A

Questions?