Q What's the deal with fiberglass and carbon-fiber rebar? I learned about these composite rebar options recently when I heard a contractor mention that their cost is now comparable to standard steel rebar. But I'm not sure how accurate my source is, or when you would use one vs. the other. And where would epoxy-coated rebar fit into the mix?

Glass FRP rebar is available in different sizes and grades for different applications. Shown here is Owens Corning's #3 Pinkbar Fiberglass rebar, which the company says is well-suited for flatwork thanks to its corrosion resistance, light weight, and ease of handling. Higher-strength fiberglass rebar for structural applications is also available.

Photo courtesy Owens Corning Infrastructure Solutions

A Bill Palmer, editor of woc360.com, a Fellow of the American Concrete Institute, a licensed professional engineer, and former editor of *Concrete Construction*, responds: Carbon steel reinforcement has been used for more than a century to provide tensile strength to reinforced concrete. This extra reinforcement is necessary because the tensile strength of concrete (in direct tension) is only about 10% to 15% of its compressive strength, so 3,000-psi concrete might have tensile strength of only 300 psi, compared with grade 60 steel, which has tensile strength of 60,000 psi.

When a load is applied to a concrete beam, it deflects or bends, and the concrete in the top half of the beam goes into compression while the bottom half is in tension. Steel is placed near the bottom of the beam, and when the concrete surrounding the steel cracks—though you may be unable to even see the cracks—the steel provides the tensile strength.

But the downside of steel in concrete is that over time, moisture, chlorides, and oxygen penetrate the concrete and result in corrosion of the steel. If the corrosion is bad enough, then the concrete beam (or column or wall) loses its tensile or bending strength. This is especially a problem in structures that are exposed to deicing salts, like bridges or parking garages.

To protect the steel, epoxy-coated rebar was invented in the 1970s. Over the past 50 years, thousands of structures have been built using epoxy-coated bars, and the epoxy coating has been mostly successful at extending the time until corrosion starts. Recently, however, some state departments of transportation have banned the use of epoxy-coated rebar after finding many bridges where the coating had debonded from the steel. It only takes a small chip in the epoxy to allow corrosion to begin and spread beneath the coating.

There are, however, some alternative concrete reinforcing materials that can be used to prevent corrosion. Stainless steel rebar is available but quite expensive, and there is galvanized rebar. Another choice is materials that combine a polymer matrix with glass, carbon, or basalt fibers embedded—fiber-reinforced polymer (FRP). These materials can't corrode, they are much lighter than steel (about one-third the weight), they don't get hot in the sun on the jobsite, and they are 4.5 times stronger in tension. And the newer bars have been designed with a gritty exterior so that they bond well to the concrete.

There are some drawbacks to FRP rebar, however. Glass-fiber bars currently cost 15% to 25% more than the equivalent steel reinforcing. Also, there are some questions about how well they perform in a fire—do they melt and lose strength? And there has been some concern about their long-term deflection or creep. The design questions have led to more conservative (and therefore more expensive) design of structural concrete elements. Another concern is that the bars can't be bent in the field but must be ordered bent from the factory.

But for light reinforcing in flatwork, where the main purpose is crack control, glass FRP rebar is quite competitive, even on a first-cost basis, and since it is so much lighter than steel, it reduces labor cost. And with its high strength, less reinforcement is needed. A couple of companies are making glass FRP rebar today. Owens Corning is promoting its glass-fiber Pinkbar (see photo, opposite page), while Neuvokas is manufacturing GatorBar in Michigan. GatorBar has both glass-fiber and basalt-fiber bars.

Buyer beware, though. Doug Gremel, with Owens Corning, says, "It's easy to cut corners by using a less costly polyester resin that won't be as durable in the alkalinity of concrete as bars made with a better vinyl ester resin that has been shown to hold up in accelerated aging and real-time tests. There are lots of very inexpensive Chinese producers of glass fibers that sell at a fraction of the cost. This is a bit like the Chinese drywall problem, in my opinion, with some of these players."

Concerning the use of carbon fiber in FRP rebar, Gremel says, "Carbon bar remains, in my opinion, still in the exotic camp. It is clearly the best material and is used smartly and appropriately for structural strengthening of existing structures. Carbon FRP bars epoxied in shallow concrete grooves in the cover of structures, like a Band-Aid, give almost miraculous additional flexural and shear capacity to the member. However, carbon bars or carbon prestressing tendons remain at least 10 times more expensive than glass FRP bars and steel rebar."

Perhaps the best solution for structural concrete that will be subjected to deicing salts is hot-dipped galvanized rebar. Galvanized bars will resist corrosion for about four times longer than carbon steel bars and the price premium is only about 10%. Galvanized bars are readily available throughout the U.S.