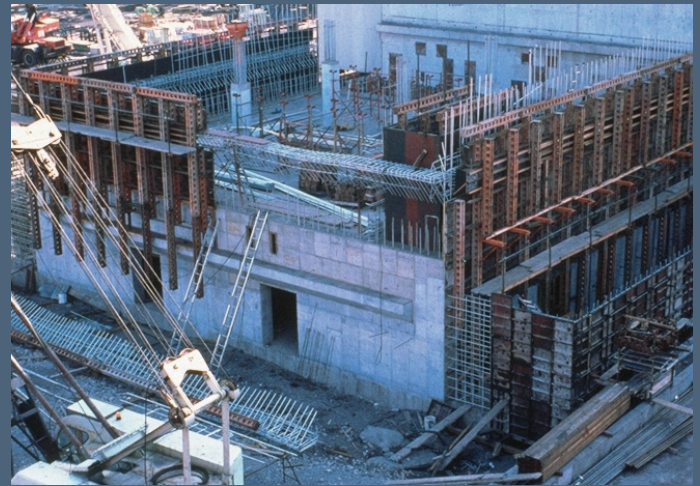


Continuously Galvanized Reinforcing Steel

The reliability of the built environment, both general construction and infrastructure, is paramount to minimize the ever increasing costs of maintenance. And avoiding the serious costs to society of disrupted transportation routes, failed communication networks, inadequate energy supply, or deficient water control systems when infrastructure must be repaired or replaced has become more critical. There is an acute demand for investments that provide long service life buildings and infrastructure.

Globally, more than \$1.5 Trillion will be spent annually over the coming years on new construction, or on repair or replacement of existing infrastructure. Whether for residential or commercial buildings, for energy, water, communications or transportation systems, construction projects will rely heavily on



Reinforced concrete construction

reinforced concrete as a principal building material. Protecting the reinforcing steel (rebar) from corrosion is a critical investment to prolong the life and improve reliability of the built environment.

Coatings are well established as a means to protect rebar from corrosion. Hot-dip galvanized rebar (HDG) has been used successfully for over 50 years although it is sometimes perceived as a niche product. A duplex (metallized zinc and epoxy coated) bar (Z-Bar™) offers good corrosion protection but is expensive. However, with about 40 years of field data it has become clear that epoxy coated rebar (ECR) offers limited and unsatisfactory protection, and it has been banned in some jurisdictions. Other costly options include stainless steel, in all its variations, including the near stainless MMFX rebar.

A new zinc based solution currently being pursued to extend the life of concrete buildings and structures is Continuous Galvanized Rebar (CGR) and a continuous Duplex Coated Rebar (DCR) trademarked as BlueBar™.

Both the CGR and DCR products have a very adherent and ductile zinc coating. The zinc coating has closely controlled thickness, and passivates quickly in concrete. The synergistic combination of the CGR zinc base coating with a barrier epoxy topcoat means DCR offers both improved corrosion protection performance and electrical insulating properties often important in the vicinity of overhead ac cables and railway catenary systems.

Rebar is a high volume steel product with over 200 million tonnes of global production in 2012. In North America, it is estimated that about 10% of the annual US rebar production is coated for protection against corrosion. There is limited data available from other regions but it is safe to assume that only a small fraction of the total worldwide rebar production is coated.



Galvanized rebar offers economical long term protection before and after installation.

A fully optimized continuous galvanized rebar process will use approximately 1.5% Zn by weight of rebar, based on a minimum 50µm (2 mil) zinc coating. Using the long experience of continuous sheet galvanizing lines as an example, it is reasonable to expect that a continuous

Continuously Galvanized Reinforcing Steel

rebar coating line will have production costs as low as 4 - 8¢/lb (\$88 – \$176/mt) of rebar, well below other competing corrosion resistant rebar costs. The low cost, zinc coated, corrosion resistant, fully formable rebar is poised to become the rebar corrosion protection coating of choice.

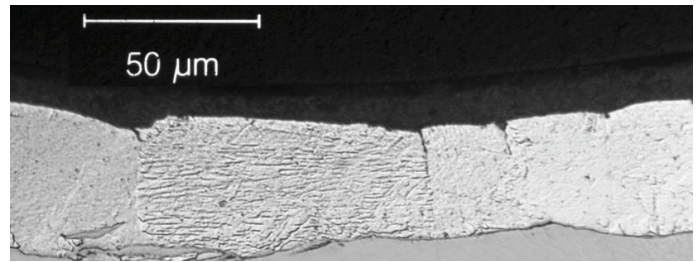
The continuous galvanized rebar process uses technology very similar to the continuous galvanizing of steel sheet used for automobile manufacturing. The steel is immersed in a zinc bath for only a few seconds, which results in a very formable coating. A metallurgical bond forms between the steel and zinc, and the coating provides both barrier coating and galvanic protection to the steel. However, the continuously galvanized bars have almost a pure zinc coating with no intermetallic layers. This coating structure is very formable, so that the CGR bars can be bent on site to very tight radii. Also, all bars would have the same thickness of coating, regardless of base steel chemistry.

Research has shown that pure zinc passivates in concrete faster and more effectively than zinc-iron intermetallics. This means that CGR provides ongoing corrosion resistance in concrete due to the large reserve of pure zinc through the coating, which affords long-term maintenance of the passive layer on the galvanized surface. It is expected that superior and more dependable performance could be achieved using the pure zinc CGR coatings.

Both the CGR and DCR products have been produced at the pilot scale on a single strand line. The construction of a commercial multi-strand line is underway. The process is simple and flexible for optimum productivity.

Continuously galvanized rebar meets ISO specification 14657 'Zinc coated steel for the reinforcement of concrete' and activity is underway to develop standards with other organizations around the globe.

Duplex galvanized coatings (organic coatings over zinc) are well known for their excellent corrosion resistance. The organic coating provides an extra layer of barrier protection, while the underlying zinc coating protects against underfilm corrosion of the organic coating, in addition to zinc's inherent corrosion resistance. A duplex continuously galvanized rebar (DCR) product called BlueBar™ with an epoxy coating over pure zinc has been produced with excellent formability and adhesion.



Continuously galvanized rebar has a pure zinc coating with no intermetallic layers.



Pilot CGR production line



Laboratory produced 'BlueBar™' showing good bending and adhesion

Photos Courtesy: Teck

For more information and details about continuously galvanized rebar, please email: contact@zinc.org



References

Tan, Z.Q., Hansson, C.M. (2008). Effect of surface condition on the initial corrosion of galvanized reinforcing steel embedded in concrete, *Corrosion Science* 50, 2512-2552
Dallin, G. Continuously coated galvanized steel reinforcing bar, April, 2013

Estimated Rebar Material Costs

Coating System	Black*	Continuously Galvanized Rebar	Epoxy*	MMFX*	Z-Bar™*	Stainless*
Estimated Cost (US\$/lb)	\$0.48	\$0.56	\$0.70	\$0.94	\$1.37	\$2.48

*Source: FHWA office of Infrastructure R&D