**INDEPENDENT EXPERT'S OPINION ON THE SCR**

**From:** Gerardo Clemena - 20th June 2010

**Subject:** The Merit of Stainless Steel Clad Bars

Mr Antonino Cacace has asked me to share with you my experience with the stainless steel clad bars. I agreed to it without any hesitation, simply because I am firmly convinced of the merit of this new construction material and, just as important, I believed in the integrity of this gentleman.

I retired in 2005 from Virginia Transportation Research Council, which is co-sponsored by the University of Virginia and Virginia Department of Transportation, after working there for 34 years, with the last 18 years or so as a principal research scientist. In that capacity, one of my two areas of focus was finding solutions that VDOT can implement to prevent the premature deterioration of concrete bridges in Virginia that were exhibiting signs of reinforcing bars corrosion. After having studied and tested different cathodic protection (CP) systems on existing concrete bridges and electrochemical extraction of chloride – even building a system into a new bridge – I came to the conclusion that, although effective in stopping bar corrosion, these measures are really not practical to implement. Further, the experience convinced me that the best approach to eliminating this costly problem of reinforcing bars corrosion is to prevent it from occurring in the first place, by using bars with significantly better corrosion resistance in all new constructions.

This led me to focus, in the last several years before my retirement, on identifying the most cost-effective corrosion resistant reinforcing bars – in collaboration with Dr. Paul Virmani, then the program manager of the corrosion program at the Turner-Fairbank Highway Research Center of Federal Highway Administration. Fortuitously, recognizing at the time the need for an affordable yet corrosion-resistant bar, some sectors of the steel industry had introduced three different new bars -- a stainless steel-clad carbon steel bar, a "microcomposite" steel (MMFX), and a zinc-and-epoxy coated bar (Zbar). Prompted by the potential benefits that these new bars may offer, we tested and compared the chloride resistances of these new bars with those of the carbon steel bar and two pickled stainless steel bars that are long known to have good corrosion resistance but, unfortunately, practically unaffordable – specifically the austenitic stainless steels 304 and 316LN.

The testing protocols and the results were published in several different VTRC reports and also described, as much as the allowed number of pages would accommodate, in a paper that was published in the November 2004 issue of the Concrete International, titled "Comparing the Chloride Resistances of Reinforcing Bars." Briefly, the testing involved embedding these different bars in separate concrete blocks, followed by weekly exposure of these blocks to wet-and-dry cycles of ponding with a solution of sodium chloride. Through regular measurements of the electrochemical states of the different embedded bars and the amount of accumulated chloride in the blocks, while the blocks were being ponded, we were able to determine the time-to-corrosion of each type of bars and, therefore, the maximum level of chloride that it was able to withstand.

The results indicated that, after more than three years of severe salt exposure, while the carbon steel bars started to corrode in 90 to 95 days, the clad bars and the stainless steel bars were still free of any signs of corrosion. Within the time frame of the study, the clad bars were as corrosion resistant as the stainless steel bars. The other two new bars didn't do as well. Recent communication with Dr. S. K. Lee, who now heads the corrosion program at FHWA and who is conducting similar tests, revealed that his data to date have confirmed our results.

Further, our comparative life-cycle cost analyses based on these results and expected cost advantage of clad bars over stainless steel bars, had demonstrated that the use of clad bars for major construction projects in severely corrosive environment will offer significant long-term economic benefits to owners.

It is worth mentioning that, through special funding from the Innovative Bridge & Highway Construction Program, we were able to actually use the clad bars in the construction of a new bridge deck in 2003. That project demonstrated that there was no need for any major adjustment to the usual construction practices.

I hope this letter has help to convey the merit of using clad bars in severe exposure environments, including coastal areas. Please don't hesitate to contact me if I could help clarify some points or answer whatever question you may have. If you desire, I could come to visit you or arrange for us to visit FHWA and see for yourself the testing currently going on at FHWA.

Best wishes,
Gerry

Gerardo G. Clemeña, Ph.D.
1206 Hatcher Court
Charlottesville, VA 22903
Tel: 434-244-2662
E-mail: gerardoclemena@yahoo.com