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Sezione Chimica Fisica Applicata – Prof. Pietro Pedeferri

I answer to the following question:

Does the presence of oxide scale formed at high temperature on the surface of stainless steel rebar influence their corrosion behaviour?

The figure reported on the section " Reval…resistant to Pitting" schematically outlines the fields of applicability of pickled stainless steels in chloride-contaminated concrete exposed to temperatures of 20°C or 40°C. Fields have been plotted by analysing the critical chloride values obtained by different Authors. Nevertheless, it should be pointed out that values are indicative only, since the critical chloride content can increase when oxygen access to the reinforcement is restricted; it can vary as when stray current or macrocells are present, and in particular it can be reduced if surface finishing is different respect to the one obtained by pickling.

Let us consider this last point. As shown in the quoted figure, in alkaline concrete pickled austenitic steels 304L (1.4307) can be safely used in concrete up to 5-6% chloride by mass of cement, austenitic 316L (1.4404) and duplex stainless steel 318 (1.4462) even higher than 6%, i.e. for chloride values practically impossible to reach in the vicinity of the steel surface.

However in presence of a welding scale on the surface of reinforcement, experience shows the lower critical chloride content is reduced to 3.5% for 304 and 316 steels. The same reduction takes place if the surface is covered by the black scale formed at high temperature during the thermomechanical treatments. Also in these case a critical content of 3.5% has to be assumed for AISI 304 and 316.

Consequently the pickling of the rebar has to be considered more efficient in pushing up the critical chloride content than the sand blasting that does not free completely the surface from the oxide scale.

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Coupling with carbon steel

There are other considerations that show the importance of a correct finishing of the surface and it is connected with the coupling of stainless steel with carbon steel Often the use of stainless steel reinforcement is limited to the outer part of the structure (skin reinforcement) or to its most critical parts. Furthermore, when stainless steel bars are used in the rehabilitation of corroding structures, they are usually connected to the original carbon steel rebars. Concern has been expressed with regard to the risk of galvanic corrosion of carbon steel induced by coupling with stainless steel bars. Experimental studies clearly have shown that the use of stainless steel in conjunction with carbon steel does not increase the risk of corrosion of carbon steel unless scale of oxides formed at high temperature are present. One of the reason is that stainless steel is a poor cathode. Consequently, the increase in corrosion rate on carbon steel embedded in chloride-contaminated concrete due to galvanic coupling with stainless steel is significantly lower than the increase brought about by coupling with passive carbon steel. However, this is not the case of stainless steel covered with welding oxide or with the black scale formed at high temperature during the termomechanical treatments. These types of scales behave as good cathode. (At least in the case of 304 and 316 steel we have tested, but also 318 should behave in the same way.) In presence of these types of scale the cathodic behaviour of stainless steel changes and the galvanic corrosion of carbon steel has to be taken in consideration. Obviously this risk can be eliminated by removing the scale by pickling.

Also in this case pickling is definetely much more effective than sand blasting that does not free completely the surface from the oxide scale.

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