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Lean duplex stainless steel: a solution to prevent corrosion for reinforced concrete exposed to severe chloride environments

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The main objective of this work is to demonstrate that for severe chloride environments, lean duplex stainless steel can be an alternative to carbon steel as reinforcement in civil engineering structures. Although the initial cost of stainless steel is higher than carbon steel, the benefit will stand in a longer lifetime without degradation of the structure and therefore less or no maintenance.

In this eight years study, corrosion of reinforced concrete was investigated depending on rebar composition (carbon steel (Fe E235) and different stainless steel grades), and corrosive conditions: in the laboratory with accelerated tests, and on site in a tidal zone with realistic corrosion evolution.

In the first laboratory work, reinforced concrete prisms were cast with chloride ions in the mix (8%_{weight} of cement) and were exposed to an aggressive environment (45°C and 92% relative humidity). The stainless steel grades considered were 1.4021, 1.4062, 1.4362 and 1.4462. The first one is a martensitic grade whereas the other three have a duplex microstructure containing both austenitic and ferritic phases in equivalent proportions.

In the second on site work, concrete beams reinforced with carbon steel or a 1.4362 lean duplex stainless steel were cast and exposed to a marine environment in a tidal zone in La Rochelle, France.

Visual inspections and electrochemical measurements such as half-cell potential, linear polarization resistance and impedance were used to investigate the corrosion behavior of the different reinforced samples (prisms and beams) versus time.

Results from the laboratory study based on measurements performed every 3 months showed that the first visual signs of corrosion degradation were observed on prisms with a carbon steel rebar after 6 months (rust and cracks) and on prisms with 1.4021 stainless steel after 33 months (rust). On the other hand, for duplex stainless steel no visual degradation appeared even after 90 months. These results were consistent with the corrosion rate values of 10, 1 and below 0.005 $\mu\text{A}/\text{cm}^2$ respectively for rebars of carbon steel, 1.4021 stainless steel and duplex stainless steels.

From the investigations conducted on the reinforced concrete beams on site, no visual sign of corrosion degradation was detected after 8,5 years. The electrochemical characterizations versus time showed different behavior based on potential values (-350 to -550mV/SCE for carbon steel and -100 to -200 mV/SCE for 1.4362 stainless steel) and on corrosion rates (corrosion current densities for duplex 1.4362 are one to two decades lower than for carbon steel).