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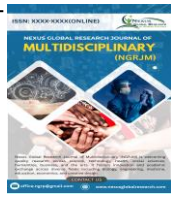

Perspective Article

Influence of Rebar Passive Layer Nano-structure on the Chloride Induced Corrosion of Steel Reinforced Concrete: A 2025 Perspective

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In the perspective of concluding 2025, life of steel reinforced concrete structures is no longer determined only by macro-scale testing but more through the nano-scale surface engineering. Corrosion protection of steel rebars embedded within the concrete is now not only governed by the alkalinity of concrete but also by the nano-structure of passive layer made up of the stable oxides of iron protecting the rebar from corrosion. This layer is a few nm thick complex film which remains stable when the pH of concrete is in the range of 12.5-13.5 in general. Modern nano-techniques such as scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), x-ray photo electron spectroscopy (XPS) etc. have made it possible to reveal the influence of rebar passive layer nano-structure on the corrosion of steel reinforced concrete.

Passive layer has a dynamic nano-structure consisting of inner layer which is primarily composed of dense crystalline magnetite which provides the major corrosion protection. The outer layer is relatively more porous which is in contact with the concrete interfacial transition zone (ITZ). The ordered nano-structure of passive layer acts as an excellent kinetic barrier which does not allow harmful corrosion initiating ions to reach the rebar. A major threat to the decay of this protective nano-film is from the chloride ions. According to the 2025 perspective, at a certain percentage of chloride ions threshold value, the chloride ions following adsorption induced pitting nucleation theory displace the oxygen atoms in the nano-structure of the layer. In this perspective instead of general thinning of the passive film, a localized pitting collapse occurs on the nano-structural level. These are known as the nano pits where the pH drops locally making it difficult to maintain passivity. As a result, rusting of iron initiates which ultimately causes macro-level cracking and destruction of concrete cover protecting the steel reinforcement bars.

In the year 2025 and beyond the advancements in the nano-engineering are now focusing on the breakthrough areas of nano-sensing, nano-alloying and surface nano-modifications. The latest research is now focused on introducing alloys such as chromium at the nano level. Thus, reducing the electrical conductivity of the passive layer and making it corrosion resistant. The in-situ nano-sensing has enabled the use of electro-chemical impedance spectroscopy (EIS) to monitor the passive layer in real time and space domains with polarization resistance and shifts in the capacitance. This has enabled the technology to predict the corrosion of steel reinforced concrete structures years before the actual cracking occurs. Overall, concluding the perspective for 2025, it can be said that the nano-engineering of passive layer will surely produce a defect free film which will guarantee the safety of this world at the macro scale by producing immortal rust-free civil engineering infrastructure.

Keyword: Nano-structure, Passive layer, Steel rebar corrosion, Chloride ions, Nano-engineering, Durability

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