XV International Conference on Durability of Building Materials and Components
DBMC 2020, Barcelona
C. Serrat, J.R. Casas and V. Gibert (Eds)

Analysis of Steel Bars in Corrosion Process after 70 Years of Natural Aging

Francieli Schmoeller[1], Maryangela G. Lima[2] and Silvelene A. Silva[3]

[1] Instituto Tecnológico de Aeronáutica (ITA), Dept. of Civil Engineering, Marechal Eduardo Gomes Sq., 50, 12228-900, São José dos Campos-SP, Brazil, francieli.schmoeller@gmail.com

[2] Instituto Tecnológico de Aeronáutica (ITA), Dept. of Civil Engineering, Marechal Eduardo Gomes Sq., 50, 12228-900, São José dos Campos-SP, Brazil, magdlima@gmail.com

[3] Instituto de Estudos Avançados (IEAv), St. Coronel Aviador José Alberto Albano do Amarante, 01, 12228-001, São José dos Campos-SP, Brazil, lenisoni@uol.com.br

Keywords: *Corrosion, Steel Bars, Microstructure, Deterioration, Natural Aging.*

1 Introduction

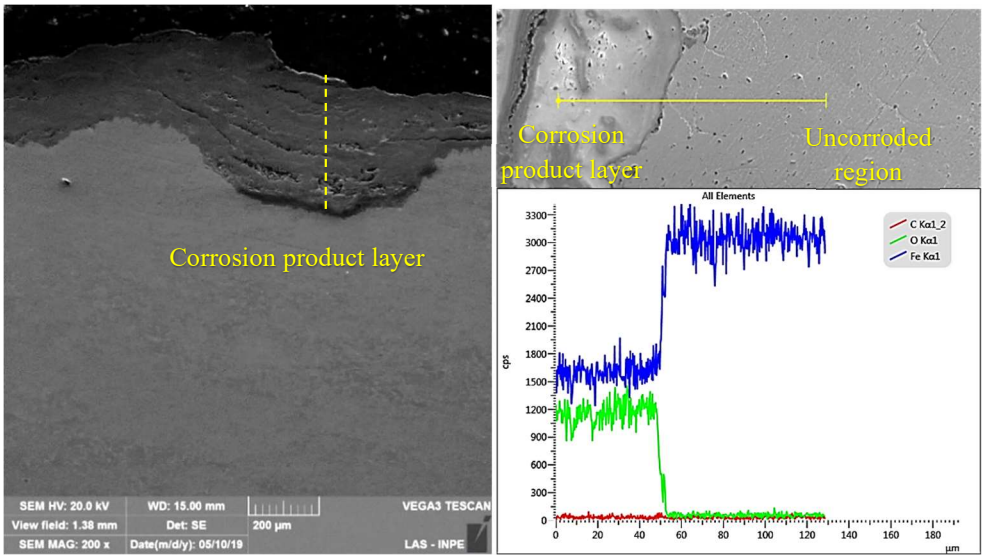
Reinforced concrete is very used in civil construction how structural element. Consequently, the incidence of deterioration in this type of structure is increasing, mainly problems related with corrosion (Bossio *et al*., 2015). Necessity to better understand this degradation process, in order to improve the quality and performance of structures, resulted in the microstructural study of steel bars at 70-year-old that aged naturally. For this, were used scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS) and mechanical tensile test.

2 Methods

Three steel bars (37-CA class) composed the sample, that were cut to 10 mm (0.39 in.) in length and metallographic preparation was performed to preserve the corroded edges. SEM was used to analyze the samples general structure, allowing the visualization of grains and grain boundaries. EDS Linescan technique allowed the comparison of samples chemical composition between the grains not corroded in relation to the corrosion products layer. And tensile test was performed to analyze the material behavior during the test until its rupture. It is possible to compare to the minimum resistance required by the standard.

3 Results

Through microstructural analysis was possible to observe the homogeneity in specimen grain structure, as well as two distinct grain tones, some grains are lighter than others, characteristic of different phases. Figure 1 (a) shows the presence of corrosion product layer formed, with irregular edges wear, as well as different corrosion depths from 62.38 μm to 381.20 μm. And Figure 1 (b) exhibits the variation of main chemical elements, checking the variation in oxygen and iron concentration, from the center to the corrosion layer. A high concentration of iron and an insignificant amount of oxygen were found in the non-corroded región, and upon reaching the corrosion layer, the iron concentration drops abruptly and the oxygen concentration increases. In addition, several micro-cracks were seen in the corrosion layer, showing the material's fragility.



(a) (b)

Figure 1. SEM image (a) of corrosion product layer (b) EDS Linescan image.

Mechanical tensile test obtained the bars strength limit, following ASTM E8.E8M: 2016. Comparing the results, strength values ranged between 338 MPa and 385 MPa (around 12 %). Regarding the minimum elongation, a difference was greater, 23 %. Standard ABNT EB 3:1939 defines the minimum strength tensile of 370 MPa for these steel bars (37-CA class). Only one specimen comply with the standard resistance and other one comply with the minimum elongation of 18 %. Then, no specimen fully complied with the standard.

4 Conclusions

The corroded layer in different depth shows an irregular corrosion process of the bars. In this layer, several microcracks were found, confirming its fragility. By EDS test illustrated the difference between uncorroded and corroded region, with the greater presence of oxygen from the corroded layer. And mechanical tensile test indicated no specimen fully complied with the standard resistance and minimum elongation. Steels bars exhibited advanced state of corrosion. These results showed the high degradation in steel after 70 years of natural aging.

ORCID

Francieli Schmoeller: https://orcid.org/0000-0003-1384-1880
Maryangela Geimba de Lima: https://orcid.org/0000-0002-0046-3991
Silvelene Alessandra Silva: https://orcid.org/0000-0003-1601-5373

References

American Society for Testing and Materials. (2016). *E8/E8M. Standard test methods for tension testing of metallic materials.* Pensilvânia.

Associação Brasileira de Normas Técnicas (1939). EB-3. *Barras laminadas de aço comum para concreto armado*. Rio de Janeiro.

Bossio, A., Monetta, T., Bellucci, F., Lignola, G. P. and Prota, A. (2015). Modeling of concrete cracking due to corrosion process of reinforcement bars. *Cement and Concrete Research*, 71, 78–92. doi: 10.1016/j.cemconres.2015.01.010