

The Efficiency of Fly Ash Concrete in the Context of the Combined Action between Chlorides and Carbonation

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1 Introduction

To reduce the environmental impact of the building sector is essential to reduce the cement consumption and to guarantee the long-term durability of concrete structures. The incorporation of fly ash (FA) in cementitious matrices has been used in two main ways. First, to reduce the cement consumption without loss of mechanical strength. Second, to increase the concrete structures durability, making its cementitious matrix more resistant to the action of chlorides. The aluminates present in FA chemically react with free chlorides binding them and reducing the amount of free chlorides able to penetrate into concrete (Alonso Alonso, Acha and Andrade, 1994). However, the consumption of $\text{Ca}(\text{OH})_2$, due to the pozzolanic reactions, decreases the alkalinity of the concrete and resulting in a more rapid carbonation when compared to a concrete made without FA (Neville, 1997). In this sense, it is necessary to investigate the efficiency of FA concrete in the context of the environment containing chlorides and carbon dioxide.

2 Experimental Program

Two different concretes were cast, a FAC (40% FA) and a reference concrete (RC), that is a concrete with similar properties to FAC but without FA. After 90 days humid curing, half of specimens were subjected to accelerated carbonation (20°C, 55% RH and 4% CO_2) during 1, 2 and 7 months (CEN/TS12390-12, 2010). The other half was protected and remained in laboratory during the same period. Afterwards, non-steady-state migration tests were performed (LNEC E 463, 2004). After 7 months test, the capillary water absorption test was carried out in order to study the open porosity of concrete (LNEC E 393, 1993).

3 Results and Discussion

The effect of carbonation on the chloride diffusion coefficient in FAC is evaluated in Figure 1 (left). There is a significant increase in chloride diffusion coefficient for FAC subjected to the combined situation when compared to the reference situation. This increase is quite high since the first month and gradually increases, until reaching the value of 352% in the seventh month. The increase in the chloride diffusion coefficient can be related to: the increase in the large capillary pores, caused by carbonation (Ngala and Page, 1997), which, in this case, can provides a "privileged path" for the chlorides penetration; and the chloride binding capacity reduction in

carbonated concrete, consequently, there are more free chlorides available to penetrate in the matrix. The capillary water absorption results show a higher capillary absorption coefficient for the specimens under combined situation when compared to the ones under reference situation. It can indicate an increase in the fraction of the large capillary pores in FA concrete carbonated.

It also important to compare FAC performance to RC performance in the same environment (Cl^- and CO_2). According Figure 1 (right), regardless the test period and carbonation depth, the chloride diffusion coefficients for FAC is always less than the chloride diffusion coefficients for RC. However, the carbonation depths for FAC is always higher than the carbonation depth for RC. In the seventh month, the carbonation depth for FAC is very close 30 mm. Taking into account the minimum coatings recommended by standards for carbonation environment, in this case, carbonation front can be close to the concrete reinforcement.

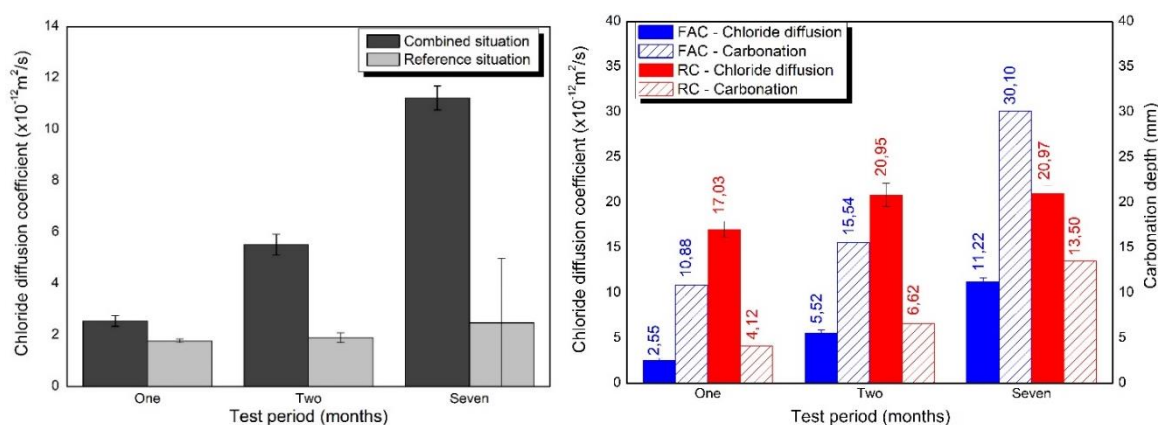


Figure 1. Left: Chloride diffusion coefficient for FAC under combined and reference situations. Right: Chloride diffusion coefficients and carbonation depths achieved for FAC and RC under combined situation.

4 Conclusions

There is a significant increase in chloride diffusion coefficient for FAC subjected to the combined situation when compared to the reference situation. This increase can be related to the increase in the large capillary pores, caused by carbonation, and the chloride binding capacity reduction in carbonated concrete. Despite it, under chloride and carbon dioxide presence, the chloride diffusion coefficient for FAC is always less than the chloride diffusion coefficient for RC. However, the carbonation depth is significant.

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