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

Influence of Different Types of Metakaolin on Compressive Strength and Chloride Migration of Concrete

Rodrigo Teodoro[1], **Helena Carasek**[2] **and Oswaldo Cascudo**[3]

[1] Laboratory of Technological Innovation in Civil Construction (LABITECC), Federal University of Goias (UFG), Goiania, Brasil, rodrigoteodoro.eng@gmail.com

[2] Laboratory of Technological Innovation in Civil Construction (LABITECC), Federal University of Goias (UFG), Goiania, Brasil, hcarasek@ufg.br

[3] Laboratory of Technological Innovation in Civil Construction (LABITECC), Federal University of Goias (UFG), Goiania, Brasil, ocascudo@ufg.br

Keywords: *Durability, Chloride Migration, Metakaolin, Compressive Strength.*

1 Introduction

Metakaolin (MK) is a relatively new supplementary cementing material (SCM), in Federal University of Goias (UFG), in Brazil, since 2000's several experiments were conducted with MK and other pozzolan, which results suggest that the overall good performance of highly reactivity metakaolin owes mainly to its fineness which leads to an enhancement of filler effect on concrete microstructure.

Thus, a research conducted to verify the influence of physical, chemical and mineralogical characteristics of highly reactivity metakaolins in mechanical and durability related properties of concrete. In the present paper the changes in compressive strength and chloride migration caused by MK properties were assessed.

2 Experimental Program

Eight different types of concrete were mixed: with two water/binder ratios – 0,40 and 0,60 – as well as three different metakaolins – MK1, MK2 and MK3 – in a 10% content in substation of cement, in mass, and a plain concrete – with no MK - R. Metakaolin's physical, chemical and mineralogical properties were analyzed, as well as the pozzolanic index of metakaolin measured by the Chapèlle's modified test. An ordinary Portland cement (OPC) (Brazilian type CP II F 40, similar to CEM II/A-L 42.5) was used. There were also used two different fine aggregates and two different coarse aggregates, and a polycarboxylate-based superplasticizer.

Concrete mixtures were tested in fresh state in which slump test was conducted to be kept in the range that was proposed (120 ± 20 mm). Then cylinder specimens were molded for tests in hardened state. Then they were cured immersed in water saturated of calcium hydroxide, at (23 ± 2)°C until the age of 28 days. Compressive strength tests were conducted with cylinder specimens (100 x 200 mm) of every concrete mix in four ages: 7, 28, 91 and 140 days. The chloride resistance was measured by the method described in NT Build 492 (Nordtest, 1999), which results in a coefficient of migration of chlorides in a non-steady state. The results were also submitted the statiscal analysis of variance (ANOVA) and multiple mean comparison, from which some charts are presented herein.

3 Results and Discussion

Although the metakaolins are produced by the same manufacturer, they are quite different. The pozzolanic index measured by the Chapèlle's modified method gives an overall understanding of the reactivity of the metakaolin, once it emulates the pozzolanic reaction (Quarcioni, Chotoli, Coelho, and Cincotto, 2015). According to this method, MK3 is the higher in reactivity, followed by MK2 and MK1, respectively.

From the results of compressive strength, even in early ages MK concrete showed better results, which may be explained by the filler effect that is instantaneous. Also, at later ages MK concretes still showed better results. For the 0.60 concretes, MK3 presented the highest results, though for the 0.40 concretes, MK2 showed the higher value. This can be explained by the differences in the pore structure of the two groups of concrete.

In chloride migration tests, MK concretes significantly outperformed plain concretes. It is noteworthy that even the worse result of MK concretes is way better than plain ones, this means that MK can significantly improve the chloride resistance of concrete, and it is more efficient in doing it than a reduction of w/b ratio. A possible explanation for this behavior can be due to the reaction of the chloride ions with the alumina present in metakaolins, thus forming the Friedel's salt (Talero, 2012). It can be also combined with the densification of the cement matrix that is assumed to occur with the addition of MK, once the compressive strength was also improved.

5 Conclusions

- The pozzolanic activity index measured by the Chapèlle's modified method showed to be accurate to describe the overall behavior of the metakaolin.
- Compressive strength was improved by the addition of metakaolin.
- Metakaolin significantly enhanced the chloride attack resistance of concretes.

Acknowledgements

The authors acknowledge the contribution of Metacaulim do Brasil Company, Eletrobras Furnas, LEDMa/UFBA, LABMIC/UFG, CAPES and CNPq, as well as UFG and PPG-GECON.

ORCID

Rodrigo Teodoro: http://orcid.org/0000-0002-7302-456X
Helena Carasek: http://orcid.org/0000-0002-1170-0980
Oswaldo Cascudo: http://orcid.org/0000-0003-1879-6396

References

Nordtest. (1999). *Concrete, mortar and cement-based repair materials: Chloride migration coefficient from non-steady-state migration experiments (NT BUILD 492)* (p. 8). p. 8. Espoo.

Quarcioni, V. A., Chotoli, F. F., Coelho, A. C. V, and Cincotto, M. A. (2015). Indirect and direct Chapelle's methods for the determination of lime consumption in pozzolanic materials. *Revista IBRACON de Estruturas e Materiais*, *8*(1), 1–7. https://doi.org/10.1590/s1983-41952015000100002

Talero, R. (2012). Synergic effect of Friedel's salt from pozzolan and from OPC co-precipitating in a chloride solution. *Construction and Building Materials*, *33*, 164–180. https://doi.org/http://dx.doi.org/10.1016/j.conbuildmat.2011.12.040