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MINERALOGICAL CHARACTERISATION OF EAF AND AOD SLAGS USING ULTRAVIOLET FLUORESCENCE

Gildas ADÉGOLOYÉ, Anne-Lise BEAUCOUR, Sophie ORTOLA, Albert NOUMOWÉ

Laboratoire de Mécanique et Matériaux de Génie Civil, Université de Cergy-Pontoise, 95031 Neuville-sur-Oise Cedex, France

gildas.adegoloye@u-cergy.fr, anne-lise.beaucour@u-cergy.fr, sophie.ortola@u-cergy.fr, albert.noumowe@u-cergy.fr

Abstract

Under UV lamps, stainless steel slag aggregates have different aspects. The UV fluorescence is used as an easy and quick way to separate these slag aggregates into several mineralogical grouping. This first stage of analysis provides a mapping of slag aggregates mineralogical variations at a larger scale (on 16 x 32 cm concrete specimen for example) than it is possible with the usual chemical and mineralogical analysis. In a second step, SEM observations and EDX analysis are conducted within each group previously identified. The association of these both different analysis methods allows us to obtain more representative results of mineralogical variability within a slag aggregates sample. The mineral phases responsible for the different observed colours were identified. The size of these phases and their distribution can also influence the appearance of EAF and AOD aggregates under UV lamps.

Introduction

An interesting valorisation way of stainless steel slag is its use as aggregates in concrete. Mineralogical studies are therefore necessary to research the mineral phases of EAF and AOD slags which could lead to concrete volume instability (MgO, CaO, ß-Ca_2SiO_4). This paper shows that ultraviolet lamps can help to identify the mineral composition of stainless steel slag aggregates (EAF and AOD slag).

Methods and materials

In this study, two types of materials were tested: EAF aggregates and stabilised AOD aggregates containing stabilised dicalcium silicate phase ß-Ca_2SiO_4. Their size fraction is 4-20 mm. This study was conducted in three steps. First of all, an identification of aggregate's groups according to their fluorescence under UV lamps was realised with two wavelengths (254 nm and 365 nm). Then, for each identified group, x-ray diffraction analysis and SEM observations with mapping by EDX were performed. At last, links between mineral phases and UV fluorescence colours were proposed.

Results and discussions

Mineral phases identified by x-ray diffraction analysis

X-ray diffraction analysis show that EAF slag aggregates contains oxides (chromium spinels $MgCrO_4$, perovskite) and silicates (akermanite $Ca_2Mg(Si_2O_7)$, merwinite $Ca_3Mg(SiO_4)_2$, andratite $Ca_3Al_2FeSi_3O_{12}$, cuspidine $Ca_4Si_2O_7F_2$, rankinite $Ca_3Si_2O_7$). For stabilised AOD slag aggregates, the mainly mineral identified phases are dicalcium silicates ß-Ca_2SiO_4, fluorite CaF_2, calcium sulfide CaS and periclase MgO.

Identification of aggregate's groups according to their UV fluorescence

Under UV lamps, stainless steel slag (EAF an AOD) have different aspects.

Most of EAF slag aggregates glow under ultraviolet lamps. The shinning ones represent less than 15 vol% of the aggregates visible on the surface of the concrete specimen and have an orange colour under short UV lamps. A very small amount of EAF slag aggregates glows purple under short and long UV.

Most of stabilised AOD slag aggregates appear orange and some fluoresce blue under UV lamps. The Table 1 summarises the different aggregate's groups highlighted under UV lamps study for EAF and AOD slags.

Table 1: Aspect of EAF and AOD slag aggregates under UV lamps

		Short wave UV	Long wave UV	Proportion
EAF slag aggregate	Group 1	Not shiny	Not shiny	High
	Group 2	Orange	Not shiny	Low
	Group 3	Purple	Less purple	Very low
Stabilised AOD slag aggregates	Group 1	Orange	Orange	High
	Group 2	Orange	Purple	Low
	Group 3	Light blue	Blue	Very low

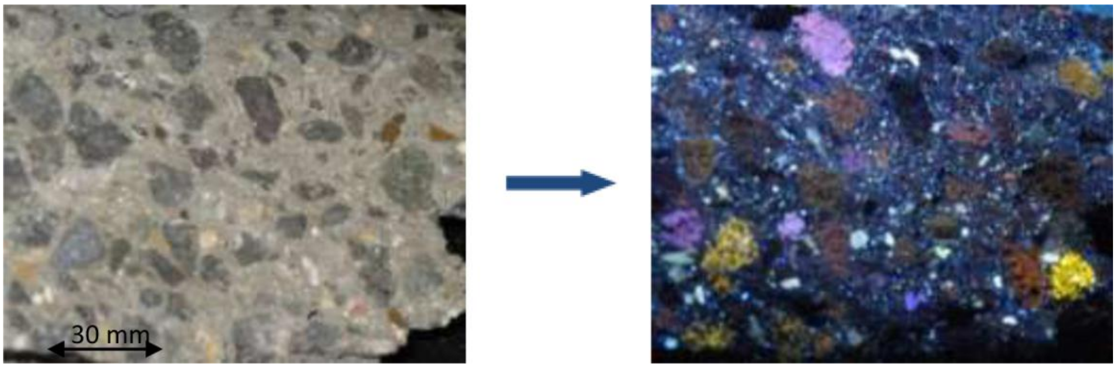

Figure 1: Concrete with EAF slag aggregates observed under short wave UV (254 nm)

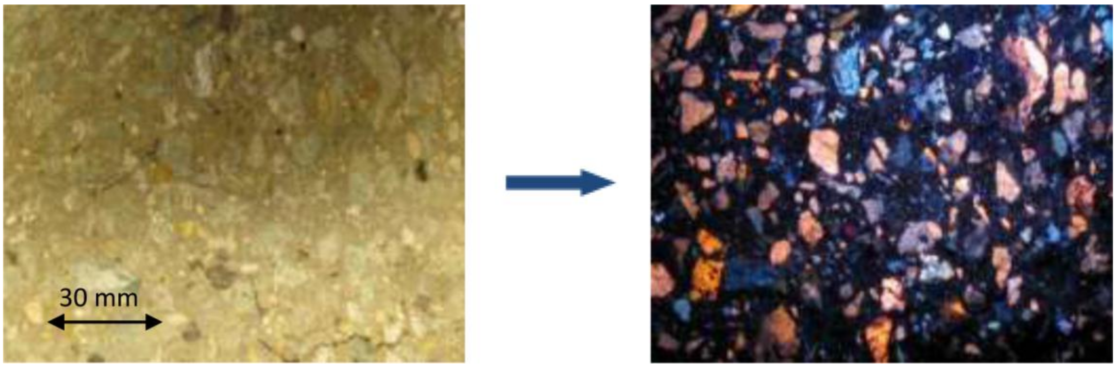

Figure 2: Concrete with AOD slag aggregates under short wave UV (254 nm)

SEM observations with EDX analysis for each group

SEM-BSE observations with Energy-Dispersive X-ray (EDX) analysis were performed on each aggregate's group in order to identify the mineral phases.

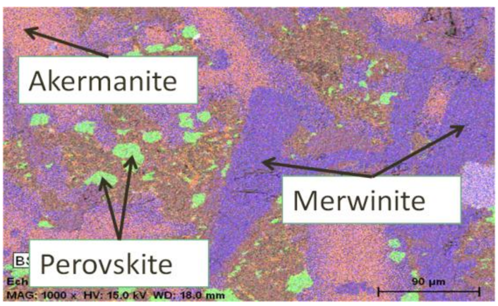

Figure 3: Group 1 EAF slag aggregates

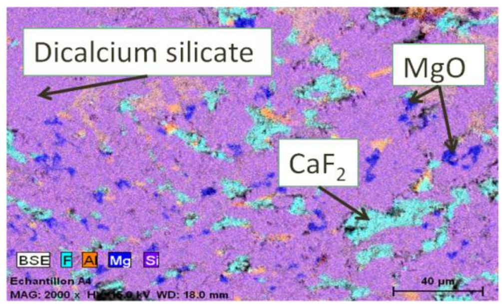

Figure 4: Group 1 AOD slag aggregates

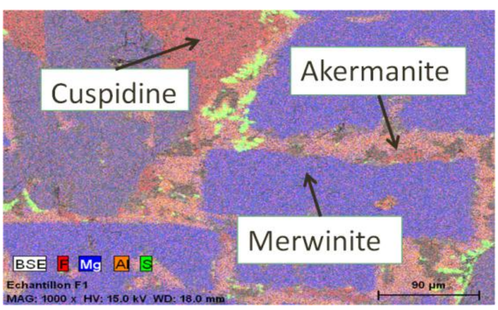

Figure 5: Group 2 EAF slag aggregates

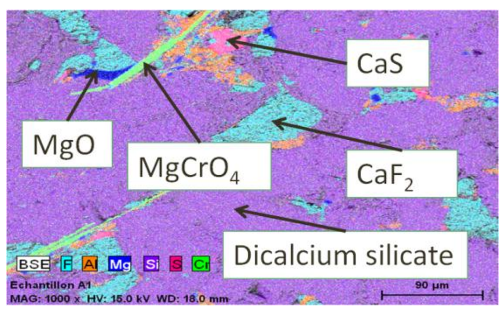

Figure 6: Group 2 AOD slag aggregates

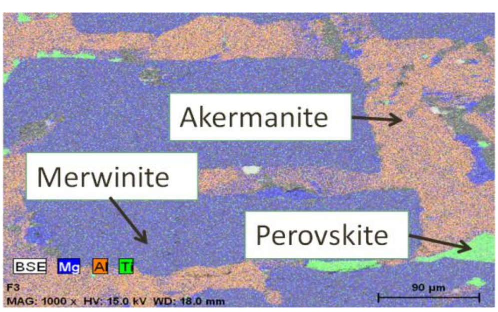

Figure 7: Group 3 EAF slag aggregates

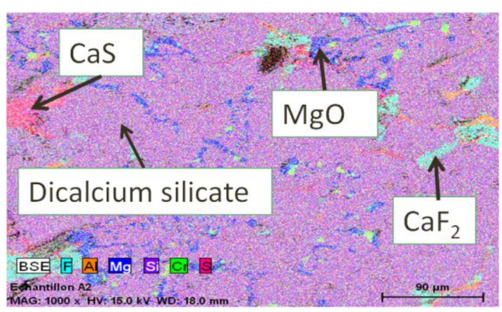

Figure 8: Group 3 AOD slag aggregates

According to Figure 3 to 8, EAF slag aggregates which don't fluoresce contain mainly akermanite, merwinite and perovskite. Orange colour of EAF aggregates under short wave UV light (group 2 EAF) may be assigned to cuspidine[3]. This mineral phase is indeed only present in aggregates of group 2.

The main mineral phases of AOD slag aggregates are beta-dicalcium silicate, periclase and fluorite. They are presents in all groups identified by UV fluorescence. The different colours under UV lamps can be explained by the proportion or the size of these mineral phases. Thus, orange colour under UV lamps of AOD slag aggregates (group 1 AOD) can be assigned of beta-dicalcium silicate (ß-Ca_2SiO_4), blue colour (group 2 AOD) to fluorite CaF_2[3] and purple colour to chromium spinels $MgCrO_4$. However, it remains an uncertainty because fluorite can appear in several colours under UV lamps according to its impurities. Further studies are needed to distinguish with certainly the fluorescence of beta-dicalcium silicate from that of Fluorite.

Mineralogical compositions of tested AOD and EAF slag aggregates are different. Major mineral phases identified in all EAF slag aggregates are akermanite and merwinite; minor phases like cuspidine or chromium oxides are present in few aggregates. Mineralogical composition of AOD slag aggregates is most homogeneous. They mainly contain dicalcium silicate and, in various proportions, minor phases like fluorite and periclase.

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