

# CALCINED CLAYS FROM DREDGING AS CEMENT CONSTITUENT - IMPACT OF FLUVIAL SEDIMENTS FROM THE SCHELDT BASIN (BELGIUM, FRANCE) ON COMPOSITE CEMENT HYDRATION

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## Introduction

Using dredging sediments from inland waterways as a resource in construction works can pose important techno-economic challenges. In areas with a strong industrial legacy, historic contamination involves high remediation and disposal costs, and alternative pathways are being sought to valorize the resource potential of problematic materials or sediment fractions. In particular the clay-silt fraction (<63 µm) is often associated with high levels of undesirable substances (organic matter, sulphides,...) or contamination that limit or prohibit their application as a resource for construction materials. At the same time, the construction industry is eager to use alternative, local raw materials that contribute to making their products and processes more sustainable from an environmental, but also techno-economic perspective. The cement and concrete industry uses large amounts of by-products or residues as supplementary cementitious materials (SCMs). To mitigate the climate impact of cement production, the demand for such SCMs is increasing, New sources are needed such as calcined clays.

In this contribution the use of calcined clays recovered from fluvial dredging sediments of three locations of the Scheldt river basin is evaluated. The impact of the calcination temperature on clay reactivity and suitability is assessed, while the impact on the hydration kinetics and mechanism of the composite cement is investigated to confirm compatibility.

### **Materials**

The studied dredged sediments originated from the Brussels-Charleroi (BC), the Ghent-Terneuzen (GT) and the Lens (L) channel. In a pretreatment step the sand fraction (> 63  $\mu$ m) was removed. The chemical composition and main physical characteristics of the dried residual fine fractions are given in Tables 1 and 2. The BC and L materials contained a high amount of organic matter, as well as high levels of heavy metals. They were calcined at 850 °C. The GT material was less contaminated and lower in organics and was calcined at 750 °C. The calcination temperatures were selected based on a reactivity screening step. The calcination reduced TOC to below detection limits, while increasing bulk density (2.82-2.94 g/cm<sup>3</sup>) and reducing specific surface area [1].

| Table 1. Material chemical composition, |                                |                             |          | Table 2. Heavy metal concentrations |                                |                             |          |
|---|--------------------------------|-----------------------------|----------|-------------------------------------|--------------------------------|-----------------------------|----------|
| main oxides, TOC and TC.                |                                |                             |          | and physical characteristics.       |                                |                             |          |
|   | Brussels-<br>Charleroi<br>(BC) | Ghent-<br>Terneuzen<br>(GT) | Lens (L) |                                     | Brussels-<br>Charleroi<br>(BC) | Ghent-<br>Terneuzen<br>(GT) | Lens (L) |
| Unit                                    | Wt.%                           | Wt.%                        | Wt.%     | Unit                                | mg/kg dm                       | mg/kg dm                    | mg/kg dm |
| Al <sub>2</sub> O <sub>3</sub>          | 13.9                           | 9.9                         | 8.2      | As                                  | 55                             | 12                          | 21       |
| SiO,                                    | 40.8                           | 61.8                        | 32.2     | Cd                                  | 127                            | 5                           | <10      |
| CaO                                     | 2.6                            | 5.5                         | 10.8     | Со                                  | <10                            | 11                          | 15       |
| Na <sub>2</sub> O                       | 0.5                            | <0.7                        | 1.9      | Cr                                  | 268                            | 82                          | 126      |
| К,О                                     | 2.1                            | 1.4                         | 1.6      | Cu                                  | 269                            | 77                          | 856      |
| MgO                                     | 1.1                            | 1.3                         | 0.9      | Hg                                  | 1.5                            | 3.7                         | 1.7      |
| Fe,O,                                   | 10.0                           | 4.1                         | 4.3      | Ni                                  | 150                            | 26                          | 61       |
| SO,                                     | 1.0                            | 0.7                         | 1.0      | Pb                                  | 814                            | 116                         | 480      |
| P,O.                                    | 1.1                            | 1.0                         | 1.4      | Zn                                  | 4791                           | 591                         | 2024     |
| тос                                     | 12.0                           | 3.6                         | 10.4     | d <sub>50</sub> (μm)                | 4.0                            | 5.3                         | 7.8      |
| тс                                      | 13.2                           | 4.5                         | 13.8     | BET $(m^2/g)$                       | 16.4                           | 7.1                         | 9.7      |

#### Performance - compressive strength

Compressive strength development for the calcined dredging material cements is slower than neat Portland cement (PC), but more rapid than a reference fly ash (FA) composite cement. Calcined L performed best and reached PC strength levels by 28 days. GT and BC still performed better than FA.



#### Conclusions

The composite cement hydration studies confirm that fluvial sediments from the Scheldt basin calcined at 750-850°C act as reactive SCMs that enhance the hydration of Portland cement through filler and pozzolanic effects. The pozzolanic reaction of the calcined sediments is enhanced by curing at higher temperatures.

#### Methods

Composite cements were formulated based on blends of Portland cement (CEM I 42.5 N) (70 wt.%) and calcined dredging clays (30 wt.%). The hydration kinetics and mechanism of these composite cements were investigated by:

- Compressive strength on mortar bars (EN 196-1)
- Hydration kinetics by isothermal calorimetry
- Hydration product assemblage by XRD and TGA

The robustness of the composite cement to changes in curing temperature (5, 20, 40  $^{\circ}$ C) are reported here.

## Hydration kinetics and products



The temperature dependence of the dredging sediment cements was found to be comparable to that of PC, hydration was faster than in FA cement, likely due to a filler effect at early ages. The pozzolanic reaction consumed Ca(OH)2 (CH), this was clearly visible from 28 days onwards. Calcined dredging sediments contributed to the formation of ettringite (Ett) and hemicarboaluminate (Hc) when cured at 5 and 20 °C.

#### Acknowledgements and references

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[1] H. Kamyab et al. (2019) Evaluation of calcined dredged sediments as supplementary cementitious materials.  $2^{nd}$  ICSBM, Eindhoven, NL.