



HAL
open science

High performance mortar using flash calcined materials

Ali Alloul, Mouhamadou Amar, Mahfoud Benzerzour, Nor Edine Abriak

► To cite this version:

Ali Alloul, Mouhamadou Amar, Mahfoud Benzerzour, Nor Edine Abriak. High performance mortar using flash calcined materials. NOMAD 2022 - 4e conférence internationale francophone Nouveaux Matériaux et Durabilité, IMT Mines Alès; LMGC; LIFAM, Nov 2022, Montpellier, France. hal-03879522

HAL Id: hal-03879522

<https://hal.science/hal-03879522v1>

Submitted on 30 Nov 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

High performance mortar using flash calcined materials

Ali ALLOUL¹, Mouhamadou AMAR¹, Mahfoud Benzerzour¹, Nor-Edine Abriak¹

¹ Univ. Lille, ULR 4515 - LGCgE, Laboratoire de Génie Civil et

Géo-Environnement, F-59000 Lille, France

2. IMT Nord Europe, 59500 Douai, France

ABSTRACT

The construction industry high production of ordinary Portland cement (OPC) leads to high CO₂ emissions which is impacting the environment negatively through climate change and global warming. High performance concrete (HPC) is a type of concrete with low water content relative to the binder, which is necessary to achieve certain mechanical properties such as high compressive strength and durability, thus achieving high service life with minimal maintenance (de Matos, Sakata and Prudêncio, 2019). This study focuses on treating supplementary cementitious materials (SCMs) by flash calcination (FC) to use them in mortar formulations for achieving high compressive strength and improved workability. Flash calcination is an efficient heat treatment technique used to eliminate organic matter and activate clay phases resulting in producing better pozzolanic properties (Amar *et al.*, 2021). The SCMs used are metakaolin (MK), flash calcined sediments (FCS), and flash calcined excavated clay (FCC).

Keywords Flash calcination, High performance mortar.

I. INTRODUCTION

Unfortunately, the construction industry has a large negative impact on the environment. Since concrete is widely used in all construction projects, then ordinary Portland cement (OPC) production demand must be very high.

Dredged sediments are highly contaminated material with large water quantities and high organic content that are available in large quantities in marines and harbors (Amar *et al.*, 2021)(He *et al.*, 2020).

Due to infrastructure and development projects, the annual generation of excavated soils in France is 130 million tons (Coussy *et al.*, 2019). Therefore, the presence of excavated soils in large quantities accumulated from such projects allow their usage as SCMs.

In order to achieve SCMs with good characteristics, they should undergo a treatment process before usage. Similar to normal calcination, flash calcination is a heat treatment method used on finely crushed materials under high temperatures (Salvador and Pons, 2018)(Amar *et al.*, 2021).

Usually, high performance concrete (HPC) requires high binder content with low water quantities to achieve high strength and high durability. In Europe, HPC is considered to be a concrete of high strength at 28 days with values higher than 60 MPa, and with low water-binder ratio (<0.4) (Sobolev and Soboleva, 1998).

II. Material and Methods

The cement used is CEMI 52.5 MPa has a density of 3.15 g/cm³. The SCMs used to replace OPC are MK, FCS, and FCC. MK is a pozzolanic material obtained from the clay mineral kaolinite calcined at 650-800°C. Both the sediments and excavated clay are obtained from marines and projects in France and flash calcined at IMT NORD EUROPE at 750°C. Their physical characteristics are shown in **Erreur ! Source du renvoi introuvable.**

Binders	Density (g/cm ³)	BET (cm ² /g)
CEMI	3.15	12619
MK	2.60	135942
FCC	2.71	330110
FCS	2.63	274587

Table 1: Physical characterizations

FC is a heat treatment technique more efficient and innovative than normal calcination since it consumes less energy, completely eliminates organic matter, and activates some of the sediment phases (including clay phases) resulting in the attainment of pozzolanic properties (Amar *et al.*, 2021). In this study, FC for fine sediments and clay particles resulted in better physical properties and elimination of organic content.

III. Mix Design

A water to binder ratio (w/b) of 0.33 and binder to sand ratio (b/s) of 0.33 were chosen for all mixtures with a constant SP percentage (2% of the total binder mass) to compare the effect of each SCM on HPM properties such as workability and mechanical strength under the same conditions. All mortar specimens are made by using steel molds of size 4 x 4 x 16 cm and compacted with a compacting table for 1 minute per layer to remove any air voids available. Then the specimens were demolded after 24 hours and cured under water at room temperature. This study is based on volume substitution of only one SCM with replacement levels 0%, 10%, 20%, and 30%. MK formulations (Mk1, Mk2, Mk3), FCS formulations (FCS1, FCS2, FCS3), and FCC formulations (FCC1, FCC2, FCC3) formulations corresponds to 10%, 20%, and 30% of OPC substituted by MK, FCS, and FCC, respectively.

IV. Result and Discussion

The reference C0 mix, prepared without the addition of SCM, exhibited an early age strength of 50 MPa from the second day and a non-early age strength of 78 MPa after 28 days of molding. Unlike OPC, Mk didn't show an increase in the compressive strength at early ages however after 28 days MK formulations MK2 and MK3 showed an increase in the compressive strength to reach a maximum of 82 MPa and 83 MPa, respectively. Both FCS and FCC have a positive effect on compressive strength with a decrease in workability. On both days 7 and 28 the compressive strength of FCS1, FCS2 and FCS3 were all higher than that of C0, namely 74 MPa, 73 MPa, 68 MPa and 88 MPa, 81 MPa, and 79 MPa, respectively. Therefore, FCS demonstrated a positive effect on compressive strength for all substitutions. The compressive strength for FCC1 has one of the

highest values of the initial analysis formulations. On the 7th and 28th day, compressive strength increased and reached a maximum of 81 MPa and 91 MPa, respectively. Thus, with substitution of 10% and 20% OPC by FCS and FCC, the compressive strength increased impressively to higher values than MK formulations which allow their usage as pozzolanic SCMs.

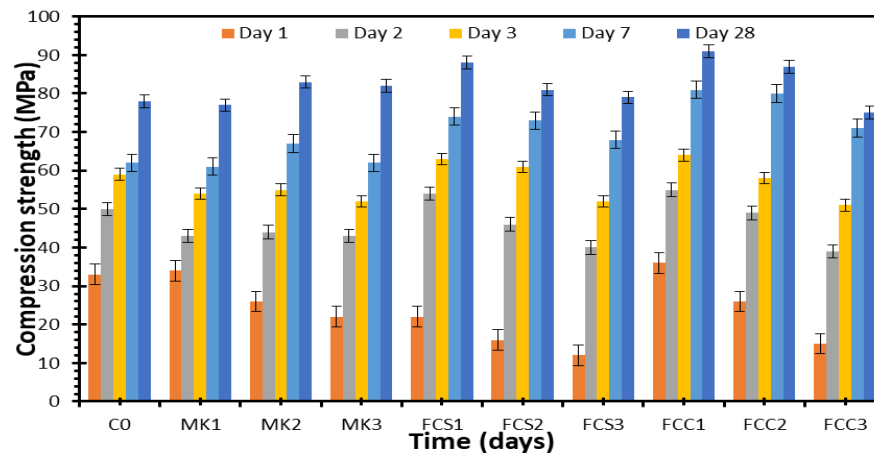


Figure 1: Compressive strength (MPa)

V. Conclusion

The HPM results shows that the flash calcined materials were able to show high strength at non-early ages which are also higher than other pozzolanic materials such as MK. A lot of studies, investigate using calcination/flash calcination as a thermal treatment method to activate pozzolanic phases in SCMs. Therefore, this study aims to show the positive effect of flash calcination on dredged sediments and excavated clays, in which the flash calcined materials were able to develop HPM with a significant strength that can be better than MK HPM formulations.

VI. References

Amar, M. *et al.* (2021) 'From dredged sediment to supplementary cementitious material: characterization, treatment, and reuse', *International Journal of Sediment Research*. Elsevier B.V., pp. 92–109. doi:10.1016/j.ijsrc.2020.06.002.

Coussy, S. *et al.* (2019) 'French Feedback on the Use of Inert Waste Landfill Criteria for Managing Excavated Soils'. Available at: www.cisapublisher.com.

He, J. *et al.* (2020) 'Strength properties of dredged soil at high water content treated with soda residue, carbide slag, and ground granulated blast furnace slag', *Construction and Building Materials*, 242, p. 118126. doi:10.1016/j.conbuildmat.2020.118126.

de Matos, P.R., Sakata, R.D. and Prudêncio, L.R. (2019) 'Eco-efficient low binder high-performance self-compacting concretes', *Construction and Building Materials*, 225, pp. 941–955. doi:10.1016/j.conbuildmat.2019.07.254.

Salvador, S. and Pons, O. (2018) 'A semi-mobile flash dryer / calciner unit to manufacture pozzolana from raw clay soils - application to soil stabilisation To cite this version : HAL Id : hal-01697286 A semi-mobile flash dryer r calciner unit to manufacture pozzolana from raw clay soils '.

Sobolev, K.G. and Soboleva, S. V. (1998) 'High-performance concrete mixture proportioning', *American Concrete Institute, ACI Special Publication, SP179*, pp. 421–438. doi:10.14359/6053.