Reuse of a dredged fluvial sediment from Wallonia as partial replacement of sand in concrete for a cycle path

M. Chabannes[1,2], J.-R. Minane[1,2], F. Becquart[1,2], C. Alary[1,2*], M. Henry[3], L. Haouche[4]

[1]IMT Lille Douai, LGCgE-GCE, F-59508 Douai, France
[2]Université de Lille, F-59000 Lille, France
[3]Centre Terre et Pierre, B-7500 Tournai, Belgique
[4]ISSeP, B-7340 Colfontaine, Belgique

*E-mail: claire.alary@imt-lille-douai.fr

Introduction: This experimental study is part of the VALSE Interreg France-Wallonia-Flanders program. The waterways between the north of France and Belgium are highly interconnected and subject to a large accumulation of sediments. If it gets too much, this siltation not only tends to hamper the navigation but it can also alter the quality of water resources [1]. The manager of Walloon waterways (SPW-DGO2) has to deal with about 250,000 cubic meters of sediments per year. As a result, it is necessary to periodically remove these sediments. The fluvial sediments from Wallonia are known to have a dominant grain size in the clay or silt grades. In addition, they usually show high levels of organic and inorganic pollutants owing to the industrial history of the area. Hence, according to the SPW, two-thirds of dredged sediments are heavily contaminated. In view of the environmental context, the reuse of sediments for civil engineering applications appears to be a suitable alternative to land disposal. The objective of the present investigation is to reuse the Walloon sediment as partial replacement of sand in concrete for an application in cycle path. As such, it will be necessary to ensure that pollutants leached out from the concrete do not exceed the threshold limits.

Methods: The Walloon fluvial sediment comes from the Charleroi-Brussels Canal. First, it was dehydrated in a lagoon. Thereafter, it was worked mechanically to loosen the clumps before being dried.
The physicochemical typology of the fluvial sediment was determined (water content, organic matter by loss on ignition, pycnometric density, humic and fulvic acids, size distribution by sieving and laser diffraction or even inorganic pollutants in the solid fraction).
The granular skeleton of the concrete (control sample) was composed of two crushed gravels (2-6 mm and 6-14 mm) from Wallonia and a river sand (0-2 mm) from Flanders. The cement used was a CEM III/A 42.5 N with 54% of clinker and 43% of GGBS (i.e. Ground Granulated Blast furnace Slag). The mass fraction of each aggregate in the inert granular skeleton (gravels and sand) was set based on some roadway applications in France and Belgium. With regard to sand, the mass fraction was 32% (control). The sand was replaced by the sediment at 12.5%, 25% and 35%. The higher replacement rate of sand was chosen in light of the fines content in the Total Granular Skeleton TGS (including gravels, sand and sediment). This fines content did not exceed 10% of the TGS to ensure a proper workability of concrete. In addition, a superplasticizer was added into the mix at 1.5% of the weight of cement. The target cement content was 330 kg.m^{-3}. The water-on-cement mass ratio ranged from 0.64 (control) to 0.95 (replacement rate of 35%) to keep a constant workability.
Mechanical properties of specimens were measured after 7, 28 and 90 days of curing in order to determine both tensile and compressive strengths.

Results and Discussion: The Walloon sediment was characterized by a very high proportion of fines with 73% of particles under 63μm. The organic matter content was around 20% with a significant amount of humic and fulvic acids. Furthermore, chemical analyses showed high contents of cadmium, lead and zinc. Zinc is known to retard the hydration of cement. Sediment-based concretes showed a strong retardation of setting time (up to 6 days of delay compared to control for the concrete with the sand replacement rate of 35%, noted C35). As a result, the compressive strength of C35 at 7 days was practically zero whereas that of the control was 32 MPa. The delayed setting is probably not only due to the presence of zinc but also to the humic acids that are known to complex with Ca^{2+}, thus disrupting cement setting. After 28 days, a consequent strength gain is noted with a compressive strength of 12 MPa for C35, 25 MPa for C25 and around 47 MPa for C12.5 and control. It can be concluded that cement hydration is not blocked. With a tensile strength of 3 MPa, C25 meets the requirements in terms of mechanical properties for road application.
It remains to carefully measure the contents of leached heavy metals and petroleum hydrocarbons (PHCs) for each mix design. These results could limit the fraction of fluvial sediment in replacement of sand in order to meet with the environmental requirements.

Acknowledgements: This research is funded by Interreg V program, project VALSE
References: [1] Alary al. (2011) *Mines et Carrières.*