CERIS : Civil Engineering Research and Innovation for Sustainability

Eco-efficient binders obtained from the thermal activation of cementitious materials

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Summary

In the move toward sustainable construction, research has been carried out in recent years with the aim of reducing the economic and environmental impact of the sector. Concrete, still the most common structural option accounts for an excessive amount of CO_2 emissions from its mainstream binder, cement, extensive resource depletion, and generation of large volumes of construction and demolition waste. Since cement manufacture represents more than 80 % of CO_2 emissions in concrete production, more sustainable solutions must involve the development of new low-carbon binders. The binders developed in this Ph.D. thesis explore the possibility of recovering the hydraulic properties of existing hydrated cementitious products, by re-applying a thermal load at much lower temperatures than those employed in the sintering of clinker from natural raw materials. In fact, by keeping re-activation temperatures below 700 °C, decarbonation of limestone (a stage responsible for over 60% of total emissions) is thus avoided. Therefore, recycled thermoactivated cement can simultaneously tackle the main issues faced by the concrete industry, that other low-carbon binders cannot.

One of the major difficulties of the implementation of this methodology was the absence of an effective separation method for concrete constituents. In the parent Project (EcoHydB) of this research, such a method was developed and implemented, following the principles of magnetic separation, where a cementitious fraction with over 75% purity by volume was achieved. In a first stage, this thesis aims to optimise the thermal activation process, adjusting operational parameters such as temperature, treatment duration, and cooling. This is followed by an in-depth analysis of thermoactivated recycled cement by making a systematic and complete characterisation of its anhydrous phases and monitoring their rehydration and the development of the hydrated phases, and the evolution of the microstructure over time. Then, these binders cen be incorporated into mortars in total and partial substitution with Portland cement. The results obtained in this stage will allow the adjustment of the mortar compositions used in the next stage. Thus, concrete produced in a later stage will benefit from the knowledge gained during the mortar production stage. Concrete produced with recycled binders will be characterised both mechanically and in terms of durability. In the end, a high sustainable eco-concrete, also produced with recycled aggregates from the same waste concrete, will be attempted.

Keywords

Eco-efficient binders, recycled thermoactivated cement, eco-efficient concrete, low-carbon.

Recycled cement production and use in a closed-circular economy cycle that tackles the main issues faced by the construction and concrete industries.