Microstructure of limestone calcined-clay cements and its influence on early-age properties

PhD Candidate: Franco ZUNINO

Limestone and calcined clays are unique among the other SCMs, as they not only offer good properties when used in combination with cement, but they are also available in the effectively unlimited quantities. Limestone calcined clay cements (LC^3) are blended cements that combine clinker, limestone, calcined clay and gypsum. They take advantage of the high reactivity of calcined clay and the synergic reaction between limestone and clay, offering equivalent mechanical performance to normal Portland cement with clinker factors down to 50%.

While significant advances have been made to assess the properties of LC^3 and establish benchmark characterization procedures, there is lack of studies focusing on the influence of calcined clay grade and limestone properties on the microstructural development of the material. Previous studies at the LMC have shown that strength is proportional to the metakaolin content in clay. It was observed that 40% metakaolin content is required to achieve the same mechanical properties as a pure CEM I system, while metakaolin contents over 60% offers little additional improvement, due to a limitation in the space available for further formation of hydrates.

Therefore, this study will focus on further exploring the space filling capacity in LC^3 systems, providing general knowledge to adapt formulations according to the different types of clays available worldwide. To understand the impact of calcined clay and limestone characteristics on early-age properties such as workability and compressive strength before 7 days is required to ensure a successful field implementation of this technology. For this reason, the focus of this project will be placed on early-age performance. This research project is divided in two main parts. The first part will explore the effect of the properties of the raw materials using to blend LC^3 cements and curing conditions on microstructure development, in particular, space filling of the porosity. The relation between pore refinement and mechanical properties will be studied. The second part will explore the effect of limestone and clay particle size and the use of grinding aids on very early (rheology and setting) and early age performance of LC^3.

The results of this study will contribute to improve the knowledge regarding that can modify the microstructure of LC^3 and how this translates in changes in mechanical properties. Furthermore, a better understanding and optimization of the rheological and early-age properties, both key variables for the construction industry, of LC^3 will allow an easier transition from the laboratory to industrial scale.