

# Master thesis project at Building Technology

## Title

**Triple blends: Sustainable cements with multiple reactive components**

## Background

Cement and concrete are by far the most important materials for humanity's built environment. Over the past 20 years the cement and concrete industry has undergone major changes. The advent of organic admixtures improved application and performance of concrete to an extent not dreamt before. The European cement industry as an emitter of CO<sub>2</sub> has highly optimized the entire production chain for cement. The incorporation of industrial by-products such as fly ash and granulated blast furnace slag as cement clinker replacements is state-of-the-art and helps considerably reducing CO<sub>2</sub> emissions. However, the potential of these materials in concrete and cement has not been fully exploited yet. Up to now most blended binder systems (cement and in concrete) provide besides cement clinker only one reactive component, mostly low calcium fly ash or blast furnace slag. More potential have so called triple or quadruple blended binders with two or three reactive components besides cement clinker. The idea behind is, besides replacing more clinker against waste materials, that different waste materials in the same binder blend can interact with each other and alleviate negative effects of one waste material with a positive effect of the other. This can considerably improve properties such as chloride binding, carbonation and frost resistance. However, the reactions within those systems are not well understood yet. The study will investigate the hydration reactions of different blended binder mixes in order to gain better knowledge about the actual mechanism. This will be performed by isothermal calorimetry, powder X-ray diffraction analysis (XRD), setting time, autogenous shrinkage, SEM-EDX analysis and compressive strength testing at different times of hydration. A first evaluation of durability will be done by carrying out the Rapid Chloride Migration test on concretes, prepared with the triple blends.

## Aim/Purpose

The goal of the study is the understanding of the hydration reactions in triple blended binders and how the single components contribute to the material properties with focus on durability.

## Method

- Literature review
- Characterization of raw materials: Cement CEM I, slag, fly ash, metakaolin, silica fume
- Preparation of binder pastes: Cement-slag-fly ash, cement-slag-metakaolin, cement-fly ash metakaolin, cement-slag-silica fume
- Curing of binder pastes and early properties: Isothermal calorimetry, shrinkage, setting
- Analysis of hydration after different time periods: Phase analysis by XRD, micro structure by SEM-EDX, strength testing

## Supervisor

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**Examiner**

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