

## **ABSTRACT**

The utilisation of supplementary cementitious materials (SCMs) and blended SCMs is widely promoted for use in cement and concrete. Although it is important to characterise the reactivity of SCMs before adding them to cement and concrete, the methods for measuring their reactivity have not been focused upon. Most of the reactivity test methods assess the reactivity in the presence of calcium hydroxide (CH), but the hydration behaviour of SCMs with CH and the effect of the factors that influence the hydration are not well understood. A better understanding of the test methods that measure reactivity of SCMs and their blends will help in improving their reliability and usability.

This thesis focuses upon understanding the hydration behaviour of SCMs and their blends for characterising their reactivity. While several test methods that quantify the reactivity of individual SCMs are available, the advent of ternary cements necessitates the testing of not just the individual SCMs, but also their blends. The hydration and reactivity of SCMs and their blends was studied in blends with CH and the optimum conditions, in terms of the availability and quantities of CH, sulphates, alkalis and their combinations, for the hydration of one each of calcined clay, fly ash and slag were studied. The kinetics of hydration, phase formation, CH consumption and strength development of selected SCMs and their blends were studied using isothermal calorimetry, X-ray diffractometry, thermogravimetry and mortar compressive strengths. The hydration results indicate that the presence of silica, alumina, calcium and magnesium influences the rate of hydration, and formation of hydration products. SCMs like calcined clay and slag react faster due to the presence of alumina and their hydration behaviour varies depending upon the presence of sulphates, alkalis and the temperature. Metastable hydroxy-AFm type phases were found to be unstable at high

temperature and a reduction in compressive strength and bound water was observed due to their conversion to hydrogarnet ( $C_3AH_6$ ).

Further, the reactivity of SCMs and their blends were measured with the help of 4 different methods: modified Chapelle's test for calcium consumption, chemical shrinkage test based on bound water, heat of hydration in the presence of CH, sulphates and alkalis and lime reactivity test based on strength development. The reactivity of SCMs and blends using the cement mortar compressive strength was tested for comparing the results from reactivity test methods with 28 days and 90 days compressive strength. The hydration and development of hydrates in selected SCMs and blends were analysed under all the reactivity tests so as to understand the influence of the test conditions on the hydration reactions.

The results show that although various problems are associated with carrying out the reactivity tests both at ambient and increased temperatures, useful information can be obtained from these tests. While at ambient conditions, the rate of reaction of most SCMs is too slow to follow and characterise using standard techniques, at higher temperatures, the nature of the reactions and the products is seen to be influenced. In some cases, even phases that are usually inert, e.g. quartz, are seen to react when the temperature is increased. In some of the systems, phases such as hydrogarnet, that are usually not observed in cementitious systems at normal temperatures, were also found to be formed in the test methods. The test methods were still seen to provide important information like that capacity to react to portlandite, the relative reactivity and information about the kinetics of reactions.

This thesis presents the test methods used, the materials studied, the results obtained and the key conclusions derived from these test methods.