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Reactivity of hydraulic lime binders: A proposed laboratory testing technique

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Hydraulic limes are traditional construction materials and were the primary hydraulic binders used in mortars prior to the development of ordinary Portland cement. They have strongly re-emerged in 21st century as a restoration material, since compatibility with the original structures is one of the fundamental principles of modern conservation.

Natural hydraulic limes result from burning of marly limestones at relatively low temperatures (below 1250°C) with reduction to powder by slaking with or without grinding. Chemically, hydraulic lime might be classified as being intermediate between lime and Portland or natural cement. It possesses considerable free lime (CaO, or CaO + MgO) so that the product hydrates and slakes in water converting to calcium hydroxide. At the same time, it contains sufficient calcium silicates to give the binder its hydraulic properties. The degree of hydraulicity of these limes varies considerably and thus they are classified as feebly, moderately and eminently hydraulic. The first retains a high percentage of available lime which contributes to the setting of the binder due to the carbonation process.

Production of good quality hydraulic lime products is as much a craft as a technology. In order to produce natural hydraulic limes with high performance characteristics, it is of great importance to determine those calcination conditions in which the produced binder is composed of a great amount of soft-burned lime, which is characterized by high specific surface area and chemical reactivity.

Reactivity on slaking is tested by measuring the increase in temperature which occurs on reaction with water. Slaking rate tests provide a measure of the overall degree of reactivity of the material. Total temperature rise as long as the time required for the reaction to be completed are largely dependent not only on the available lime content of each sample but also from the intensity of the calcination conditions.

This case study proposes the laboratory testing of the reactivity of hydraulic limes that have been classified regarding their degree of hydraulicity as feebly hydraulic, according to the European standard (EN 459.02, 2002) slaking rate test. Samples of a marly limestone from Central Crete, Greece were calcined at three different temperatures (850°C, 900°C, 950°C) for 3, 6, 9 and 12 hours respectively in order to produce natural hydraulic lime. Laboratory slaking rate tests were performed for each product. X-ray diffraction (XRD) analysis was used for the qualitative and quantitative identification of the crystalline compounds present in the produced binders. The BET specific surface area and the density of the hydraulic limes produced were also measured. Based on the experimental results it is obvious that calcination conditions affect mostly the reactivity of the produced feebly hydraulic lime binders and not so much the amount of the hydraulic phases produced. Performing of slaking rate tests indicates the optimum conditions in order to obtain highly reactive hydraulic lime products.