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Synthesis of Belite Cements at Low Temperature from Silica Fume and Natural Commercial Zeolite

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Abstract : The cement industry is facing cost increments in energy supply, requirements for reduction of CO_2, and insufficient supply of raw materials of good quality. According to all these environmental issues, cement industry must change its consumption patterns and reduce CO_2 emissions to the atmosphere. This can be achieved by generating environmental consciousness, which encourages the use of industrial by-products and/or recycling for the production of cement, as well as alternate, environment-friendly methods of synthesis which reduce CO_2. Calcination is the conventional method for the obtainment of Portland cement clinker. This method consists of grinding and mixing of raw materials (limestone, clay, etc.) in an adequate dosage. Resulting mix has a clinkerization temperature of 1450 °C so that the formation of the main component occur: alite (Ca_3SiO_5, C_3S). Considering that the energy required to produce C_3S is 1810 kJ kg -1, calcination method for the obtainment of clinker represents two major disadvantages: long thermal treatment and elevated temperatures of synthesis, both of which cause high emissions of carbon dioxide (CO_2) to the atmosphere. Belite Portland clinker is characterized by having a low content of calcium oxide (CaO), causing the presence of alite to diminish and favoring the formation of belite (β-Ca_2SiO_4, C_2S), so production of clinker requires a reduced energy consumption (1350 kJ kg-1), releasing less CO_2 to the atmosphere. Conventionally, β-Ca_2SiO_4 is synthetized by the calcination of calcium carbonate ($CaCO_3$) and silicon dioxide (SiO_2) through the reaction in solid state at temperatures greater than 1300 °C. Resulting belite shows low hydraulic reactivity. Therefore, this study concerns a new simple modified combustion method for the synthesis of two belite cements at low temperatures (1000 °C). Silica fume, as subproduct of metallurgic industry and commercial natural zeolite were utilized as raw materials. These are considered low-cost materials and were utilized with no additional purification process. Belite cements properties were characterized by XRD, SEM, EDS and BET techniques. Hydration capacity of belite cements was calculated while the mechanical strength was determined in ordinary Portland cement specimens (PC) with a 10% partial replacement of the belite cements obtained. Results showed belite cements presented relatively high surface áreas, at early ages mechanical strengths similar to those of alite cement and comparable to strengths of belite cements obtained by different synthesis methods. Cements obtained in this work present good hydraulic reactivity properties.

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