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X-Ray Diffraction Characterisation of Hydrated and Calcined Cementitious Materials for Sustainable Recycling

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Resumo:
This research analyzes the mineralogical compositions of hydrated Portland cement pastes before and after calcination at temperatures of 300, 400, 500, 700, 900, and 1200°C to reactivate binder functions. The quantification of crystalline phases was done by X-ray Diffraction using the Rietveld method and TOPAS software. Part of broader research, it aims to better understand the changes during hydration, dehydration, and rehydration of cement blends. Recycling old concrete in new material production would avoid the disposal of hydrated cement binders from Construction and Demolition (C&D) directly into the environment. Proposing practical solutions for waste management to preserve natural resources and reduce emissions aligns with global efforts for sustainable development but requires continuous research, technological advancement, and regulatory support to optimize its efficacy and broaden applications. The study investigates the application of powder diffraction techniques in conjunction with mineralogical analysis using the Rietveld

method. It focuses on specimens meticulously prepared under strict conditions to evaluate the compositional variations of samples subjected to differential thermal treatments. This methodology is proposed as a model for broader application in the analysis of generic Portland cementitious waste. The intent is to refine the understanding of the structural evolution of such materials under various thermal exposures, thereby improving the accuracy of compositional analyses in recycling and waste management contexts. The thermal analysis for the experiments, preparation and molding of mixes, dehydration processes, and conventional X-ray Diffraction (XRD) are detailed in the methodology section. The study shows that the stability and transformation of Belite, Calcite, Dolomite, and Portlandite are highly temperature-dependent, with distinct behaviors for each type of mix (M1, M2, M3). The research provides a more informed assessment to find a compromise temperature for producing cementitious material with fuel economy concerns and CO2 emission minimization. In conclusion, recycling demolished concrete to produce calcium silicate-rich hydraulic materials offers a sustainable path for the construction industry, contributing to environmental conservation, resource efficiency, and greenhouse gas emission reduction. Continuous research and development in this area are vital to overcome existing barriers and realize the full potential of this innovative recycling process. The present study elucidated that the application of diffraction analysis, complemented with comprehensive mineralogical examination through the Rietveld refinement technique, serves as an effective instrument to assess the recycling potential of specific residual cementitious materials. Further investigations are necessary to optimize caloric efficiency and mitigate CO2 emissions associated with the recycling process.