

# EVALUATION OF TRANSITION FROM FLUID TO ELASTIC SOLID OF CEMENTITIOUS PASTES WITH BAUXITE RESIDUE USING OSCILLATION RHEOMETRY AND ISOTHERMAL CALORIMETRY

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## ABSTRACT:

This work evaluates the impact of using bauxite residue (BR) as filler addition in cementitious compositions, during the early ages of transformation from the viscous fluid phase to an elastic solid. Chemical reaction and consolidation (physical phenomena of hardening) were also correlated. The chemical reaction rate was accompanied using isothermal calorimetry and the consolidation measured using oscillatory rheometry (quantifying the storage modulus –  $G'$  and relating with yield stress,  $\sigma_o$ ). The results show that BR accelerates the cement hydration reaction, but in pastes with pure cement, consolidation was faster, showing a distinct effect on the fluid-solid transition.

## ZUSAMMENFASSUNG:

In dieser Arbeit wird der Einfluss von Bauxitabfällen (BR) als Füllstoffzusätze für Zementmaterialien im Anfangsstadium des Überganges von der viskosen Phase zu einem elastischen Festkörper untersucht. Die chemische Reaktion und die Verfestigung (physikalische Phänomene der Erhärtung) wurden ebenfalls in Beziehung gesetzt. Die chemische Reaktionsrate wurde mit der isothermen Kalorimetrie und der Verfestigung ermittelt, die mit Hilfe der oszillatorischen Rheometrie (Bestimmung des Speichermoduls  $G'$  und Untersuchung des Zusammenhanges mit der Fließspannung  $\sigma_o$ ) gemessen wurde. Die Ergebnisse zeigen, dass Bauxitabfälle die Hydrationsreaktion des Zementes beschleunigen. Jedoch findet in Pasten mit reinem Zement die Verfestigung schneller statt, was auf einen deutlichen Einfluss auf den Flüssig-Fest-Übergang hindeutet.

## RÉSUMÉ:

Ce travail évalue l'impact de l'utilisation de résidus de bauxite (BR) comme charge dans des compositions de ciment, pendant le commencement de la transition de la phase fluide visqueuse vers un solide élastique. Nous avons aussi corrélié la réaction chimique avec la consolidation (phénomène physique de durcissement). La vitesse de réaction chimique a été suivie à l'aide de la calorimétrie isothermique, tandis que la consolidation a été mesurée à l'aide de la rhéométrie oscillatoire (en quantifiant le module élastique –  $G'$  et en reliant avec la contrainte seuil,  $\sigma_o$ ). Les résultats montrent que le BR accélère la réaction d'hydratation du ciment, mais dans les ciments purs, la consolidation est plus rapide, montrant un effet distinct sur la transition fluide-solide.

**KEY WORDS:** oscillatory rheometry, isothermal calorimetry, cement paste, bauxite residue

## 1 INTRODUCTION

Bauxite residue (BR) is a by-product generated in large scale by the Bayer process and has high alkalinity and sodium content due to the bauxite digestion with sodium hydroxide. Although much effort and many different applications have been tried in disposing of this waste, this material is still being discarded in especially designed dams [1–7]. In recent years, an alterna-

tive application for this by-product residue has been in use as a partial substitution to or as an addition to cement in the formulation of mortars and concretes, or in the production of clinker to obtain cement [2–4, 8–15]. These practices are continuously under investigation due to the worldwide high demand for supplementary cementitious materials. Most of the investigations found in literature are studies focused on the

after 60 minutes. Considering that cement hydrates and the residue particles develop opposite zeta potentials in the alkaline pH, it is possible to infer that the BR particles are probably attached on the cement surface, thus creating a steric barrier effect, preventing direct contacts among cement particle and hydrates. This fact contributed to stabilization of the transition from viscous fluid to elastic solid state.

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