

# Investigation of Alkali-Silica Reaction in Concretes with Biomass Fly Ash

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## Abstract

The alkali-silica reaction (ASR) in concrete occurs by reaction of certain silica phases in the aggregates with alkalis and hydroxide ions in the pore solution of the hydrating cement to produce a hydrous alkali-silicate gel. This gel can swell by incorporating large amounts of water, causing severe and irreversible expansion and cracking of the concrete. The level of expansion and disruption in concrete containing reactive aggregate depends on the alkali content of the concrete and the reactivity of the aggregate. The levels of alkali that trigger the expansion depend, however, on the reactivity of the aggregates. Alkalis from Portland cement (OPC) are one of the major sources of these ions in concrete. The use of industrial by-products such as fly ash and slag has been found to be an effective preventive measure against ASR in concrete.

This article presents the performance of biomass fly ash - an industrial by-product - in the mitigation/inhibition of ASR in concrete. Laboratory expansion tests were conducted to evaluate the performance of biomass fly ash, in replacement of OPC by 20% and 30% (w/w) in the experiments (ASTM C1260/ASTM C1567). The results revealed that biomass fly ash has a good potential in the expansion inhibition due to ASR.

## Originality

In recent years, pressures on global environment and energy security have led to an increasing demand on renewable energy sources, and diversification of Europe's energy supply. Among these resources the biomass could exert an important role, since it is considered a renewable and CO<sub>2</sub> neutral energy resource once the consumption rate is lower than the growth rate, and can potentially provide energy for heat, power and transports from the same installation. Currently, most of the biomass ash produced in industrial plants is either disposed of in landfill or recycled on agricultural fields or forest, and most times this goes on without any form of control. However, considering that the disposal cost of biomass ashes are raising, and that biomass ash volumes are increasing worldwide, a sustainable ash management has to be established. It is reported that the biomass fly ash collected as wastes from the industrial plants in Portugal can be effectively used as a cement substitute. The present work aims to discuss the role of biomass fly ash on the ASR mechanism in concrete.

## Chief contributions

The biomass fly ash was collected from an industrial plant in Portugal and was sieved through 75 micron mesh and washed prior to the incorporation in mortars and concretes. The characterisation of the ash was done using different techniques such as particle size distribution, loss on ignition, TGA/DTA, XRD, XRF and pozzolanic activity test. The biomass fly ash is irregular in shape and fine in nature. The chemical characterisation revealed that the biomass fly ash is similar to a class C fly ash and contain around 25% CaO, being expected to react also hydraulically.

Accelerated mortar-bar tests were conducted according ASTM C 1260/ASTM C 1567 to evaluate the behavior of the biomass fly ash in the ASR inhibition mechanism. These mortars were done with 20 and 30% of cement substitution, in weight, by fly ash. The results obtained shown a clear reduction in expansion due to ASR in the biomass fly ash mortars. Currently, we are doing the concrete prism expansion tests according the RILEM AAR-3 and RILEM AAR-4 test methods to confirm the good response of biomass fly ash in mortar-bar tests.

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Keywords: Alkali-silica reactions; Biomass fly ash; Concretes; Industrial by-products.

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