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# A sustainable treatment method to use municipal solid waste incinerator bottom ash as cement replacement

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ABSTRACT

This paper studies the use of municipal solid waste incinerator bottom ash as a supplementary cementitious material in concrete products using an innovative chemical treatment approach. The primary objective is to address emissions associated with waste-to-energy facilities and the heavy reliance on ordinary Portland cement as the primary binder in concrete. The proposed method involves the removal of metallic aluminium from the bottom ash and the subsequent use of the treated bottom ash as a partial cement replacement to produce concrete. Concrete specimens were produced with varying proportions of treated or untreated municipal solid waste incinerator bottom ash, replacing 20%, 35%, and 55% of ordinary Portland cement according to EN 197 European standard for common cement. Moreover, class F fly ash was incorporated in equivalent percentages as a reference supplementary cementitious material, and a control mix was prepared using solely Portland cement. The evaluation encompassed multiple visual and analytical techniques, including scanning electron microscopy, X-ray diffraction, X-ray fluorescence, and setting time analyses on pastes made with Portland cement, fly ash, and bottom ash. All specimens were evaluated in terms of mechanical performance, namely compressive strength. The chemical treatment process facilitated the release of a significant quantity of hydrogen, a by-product of aluminium oxidization. Consequently, this resulted in significantly reduced formation of gas bubbles in concrete in the fresh state and, therefore, diminished expansion during the setting process. As the proportion of cement replacement with bottom ash increased, a decline in strength was observed. However, this decline was less pronounced when using treated bottom ash, particularly with lower levels of incorporation.

## 1. Introduction

The global demand for the fundamental component of concrete, ordinary Portland cement (OPC), has witnessed a significant surge in recent years. The production of OPC is expected to reach an estimated 4.1 billion metric tonnes by 2050, nearly three-fold the reported amount produced in the year 2000 [1]. This rising demand is primarily attributed to the rapid urbanization and infrastructure development seen worldwide. Remarkably, OPC-based concrete is the second most consumed material globally, being only surpassed by water [2]. This snowballing demand on OPC is strongly tangled with a severe environmental concern - $CO_2$ emissions [3]. Its production is an energy-intensive process, which involves heating limestone and clay to elevated temperatures, resulting in substantial $CO_2$ emissions [4,5]. In the year 2021, the $CO_2$ emissions released by this industry alone accounted for 8% of the global $CO_2$ emissions, making this industry the third-largest source of $CO_2$ emissions, after the energy and steel industries [1,3,6]. These statistics highlight the urgent need for sustainable alternatives to OPC in concrete production to lighten the substantial carbon footprint associated with its production and contribute to global efforts to combat climate change.

Furthermore, the substantial growth in the world's population has led to an increasing generation of municipal solid wastes (MSW) worldwide. In November 15, 2022, the world's population reached 8 billion people and is expected to reach 10 billion by 2058 [7]. According to the World Bank, the global MSW yearly generation reached 2.01

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