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# Protracted Actions of Wood Biomass Fly Ash-Contained Concrete

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## Abstract

Wood biomass is widely used as a fuel in the European Union to generate heat and electricity, resulting in a significant amount of ash. Because ash particles contain heavy metals and can easily pollute soil, groundwater, or air, proper engineering solutions are required for ash disposal, particularly in its finest fraction. In this study, wood fly ash with a high pozzolanic oxide content and one with a high CaO content were used in concrete as a 15% and 30% cement replacement, respectively. Wood ash incorporation in concrete reduced the 28-day compressive strength by up to 37%, which was attributed to the low stiffness of the wood ash particles, whereas the 2-year compressive strength indicated very low pozzolanic reactivity.

**Keywords:** Wood biomass fly ash • Compressive strength • Capillary absorption • Drying shrinkage

## Introduction

The capillary absorption of concrete increased as the ash content increased, but there was almost no effect on gas permeability. After one year, wood fly ash with a high CaO content reduced the drying shrinkage of concrete by up to 65%. Swelling occurred in the first days of hydration in a mix with 30% high CaO fly ash, which was attributed to volume expansion due to the formation of portlandite and brucite, but did not result in cracking or a decrease in long-term compressive strength.

The trend in the European Union to reduce greenhouse gas emissions from coal use has increased the use of wood biomass for energy production. In 2018, it was estimated that approximately 11 million tonnes of ash were produced by biomass combustion in the EU-28 countries, the majority of which was ash from wood biomass. It is critical that ash from wood biomass is properly managed to avoid pollution of the air, soil, or groundwater. However, due to logistical issues, different ash properties, or a lack of legislation, the majority of the ash produced is currently landfilled. Because ash from natural wood combustion contains valuable plant nutrients concentrated in the coarse ashfractions, returning it to the forest from which it originated may be the best way to manage it [1].

## Description

It has been demonstrated that fly ash can be used as a raw material in the manufacture of a variety of construction products. Today, fly ash from coal combustion is one of the most commonly used cement replacement materials in cement production, and its use as a concrete constituent is standardised. In addition to coal fly ash, many new supplementary cementitious materials are being researched to improve the sustainability of cement-based products by increasing durability or decreasing cement consumption. The cement and concrete industries have also been identified as major potential users of wood fly ash. WFA has different properties than coal fly ash. The chemical composition of WFA varies depending on the wood species and the wood pieces.

Furthermore, the physical and chemical properties of WFA particles are greatly influenced by different combustion technologies. WFA from grate combustors and fluidized bed combustors can have hydraulic and/or pozzolanic properties, despite not being as reactive as cement. Extensive research has been carried out to determine the impact of using WFA as a cement replacement material. When used as a cement replacement material, WFA degrades mechanical properties and increases water demand due to the presence of unburned carbon particles with lower stiffness than cement particles. However, substituting WFA for cement can increase strength and improve workability due to improved particle packing or activation by grinding [2].

The use of WFA in the concrete industry requires more research, particularly because most studies on the influence of WFA on the properties of cement composites have been tested on cement pastes and mortars, with only a few experiments scaled up to the concrete level. Two types of WFA with different physical and chemical properties are used as partial cement replacements in concrete in this study. The effects of the WFA admixture on the compressive strength, permeability, and drying shrinkage of concrete were studied over a year [3,4].

Wood fly ash (WFA) was collected from two power plants in Croatia. Both plants are cogeneration biomass power plants that generate both heat and electricity and use the same technology of grate combustor incineration. Power plant 1, which generates WFA1, is located in northern Croatia and has a capacity of 2.75 MW electrical energy and 15 MW heat energy. Plant1 uses beech, oak, fir, and spruce wood chips as fuel, as well as thinning residues such as twigs and tops, branches, bark, needles/leaves, and wood industry waste. Which produces WFA2, has a 1 MW electric capacity and a 4.1 MW heat capacity.

The chemical properties of the WFAs used in this study. Elemental composition was determined using X-ray fluorescence in accordance with ISO/TS standards, loss on ignition in accordance with EN, and pH value in accordance with EN. WFA1 has a CaO-Al2O3-SiO2 ratio similar to coal fly ash and a pozzolanic oxide content greater than the ASTM minimum value for class C pozzolans. WFA2 contained a high amount of CaO and a low amount of pozzolanic oxides. The density was determined in accordance with ASTM standards. Because the unburned wood particles in WFA1 tended to float on

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the petroleum, accurate density determination was difficult. There were no unburned wood particles in WFA2 [5].

## Conclusion

The results of long-term tests on concrete made with two types and two proportions of WFA as a substitute for part of the cement are presented in this paper. Over a one-year period, the impact of WFA properties and composition on the compressive strength, permeability, and shrinkage of concrete was studied. The experiments lead to the following conclusions. When the drying shrinkage of the mixes was tested over a year, a significant decrease in shrinkage was observed in the mixes containing 30% WFA compared to the reference mix; however, in the case of WFA2, the swelling deformation was also pronounced at an early age, which was most likely caused by a significant amount of free MgO and free CaO; the TG analysis revealed that the mixes containing WF2 contained brucite, which can also partially cause the increase in the initial volume. WFA1, unlike WFA2, did not contribute significantly to shrinkage reduction when compared to the reference. The potential use of high CaO WFA as a shrinkage-reducing admixture necessitates determining the optimal WFA dosage to minimise shrinkage and strength loss. According to the findings of this study, this could amount to about 15% cement replacement. It would be useful to know the relationship between WFA storage time and chemical composition for future applications.

## Acknowledgement

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## Conflict of Interest

There are no conflicts of interest by author.

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