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Use of Unprocessed Wood Ash as Partial Replacement of Sand in Concrete

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The use of unprocessed low-calcium wood ash as partial substitution of natural sand in manufacturing of concrete has been explored in the present study. X-ray diffraction (XRD) spectrum indicates the presence of amorphous as well as crystalline silica in unprocessed wood ash. The total composition of silica, alumina, and ferric of 92.93% qualifies the unprocessed wood ash to be used as pozzolanic material. Experimental tests were performed in laboratory for workability, strength, and durability properties of concrete incorporating 0, 5, 10, 15, and 20% wood ash as substitution of natural sand. It was observed that at a fixed water-cement ratio (w/c), the slump of concrete decreased on inclusion of unprocessed wood ash as partial substitution of natural sand. The compressive strength and splitting tensile strength of concrete mixtures made with unprocessed wood ash were lower than control concrete. The wood ash concrete mixtures, except the concrete mixture containing 5% unprocessed wood ash, displayed higher water absorption, sorptivity, and chloride-ion penetrability compared to control concrete. XRD analysis of powdered concrete specimens indicated no qualitative change in phase formation on incorporation of unprocessed wood ash.

Keywords: compressive strength; splitting tensile strength; wood ash.

INTRODUCTION

Worldwide, approximately 12 billion tons of concrete is manufactured annually, which requires an enormous volume of natural resources such as coarse and fines aggregates and cement production.¹ Presently, river sand and gravel are struggling to cope with the rapidly growing demand in many areas around the globe. The sources of good quality river sand and gravel are depleting very fast. As such, there is a dire need to explore supplementary materials for natural sand which can be used in the production of concrete. Such supplementary materials should satisfy the technical requirements of natural sand and should also be available in abundance. In the past, many waste materials have been successfully used either as supplementary cementitious materials or as replacement of fine aggregate in concrete manufacturing. The previous research studies have established that there is improvement in strength and durability properties of concrete on use of supplementary cementitious materials.^{2,3} Wood ash is a by-product of wood processing industry. In the United States, approximately 231 million dry tons of forest residue is produced every year.⁴ On combustion, depending upon the type of wood, 0.4% to 2.1% wood ash is generated.⁵ According to Cheah and Ramli,⁶ proper characterization of wood ash is essential prior to its use in concrete production. The quality of wood ash depends on various factors, such as combustion temperature and technology, and species of

wood. In the published research studies, processed wood ash has been tried as supplementary cementitious material in production of mortar and concrete. However, the published research studies show plummeting of strength and durability properties of concrete made with processed wood ash as supplementary cementitious material.

According to study by Naik et al.,⁷ there was insignificant variation in the strength properties of concrete containing up to 12% ground wood ash as substitution of cement. Concrete made with 8% wood ash displayed optimum strength values. However, Udoeyo et al.⁸ and Chowdhury et al.⁹ concluded that compressive strength and flexural strength of concrete mixtures incorporating ground wood ash as supplementary cementitious material decreased with increase in quantity of wood ash. Cheah and Ramli⁶ also reported a decrease in strength properties and increase in water absorption of mortar mixtures made with ground wood ash as partial substitution of cement. A similar research study by Rajamma et al.¹⁰ also shows a decrease in compressive strength and flexural strength of cement mortar mixtures incorporating ground wood ash up to 40% as substitution of cement. However, according to the study conducted by Elinwa and Ejeh,¹¹ cement mortar incorporating 10% ground wood ash displays improvement in compressive strength compared to a control mortar mixture. Another study by Cheah and Ramli¹² also illustrates improvement in durability properties of cement mortar incorporating up to 10% ground high calcium wood ash as supplementary cementitious material. According to study by Ramos et al.,¹³ ground wood ash is a promising supplementary cementitious material that improves the durability properties of cement mortar. According to this study, the expansion of mortar incorporating ground wood ash as substitution of cement decreased due to alkali silicate reaction.

RESEARCH SIGNIFICANCE

Very few research studies on the use of processed wood ash as supplementary cementitious material in the production of cement mortar and concrete are available. However, no published research study is available on the use of unprocessed wood ash as substitution of sand in production of concrete. As-received wood ash is coarser and needs to be ground prior to its use as supplementary cementitious

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