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Review Article

Structure and properties of mortar and concrete with rice husk ash as partial replacement of ordinary Portland cement – A review

Fapohunda Christopher [a,*], Akinbile Bolatito [b], Shittu Ahmed [a]

[a] *Department of Civil Engineering, Federal University, Oye-Ekiti, Nigeria*
[b] *Department of Building, The Polytechnic, Ibadan, Nigeria*

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Abstract

In order to arrest the incidence of global warming brought about by the emission of greenhouse gases notably CO_2 into the atmosphere, the use of materials that can substitute the material responsible for greenhouse gases is being promoted world-wide. One of these is rice husk ash (RHA) which has been found suitable by researchers to partially replace Portland cement in the production of concrete. This paper presents a comprehensive and up-to-date review of the work of numerous researchers on structure and properties of concrete containing rice husk ash (RHA) as partial replacement of ordinary Portland cement. Some of the findings are: (i) controlled incineration is required to produce RHA with structure that can result in structural concrete, (ii) the use of RHA resulted in increased water demand, (iii) up to 10% cement replacement with RHA will result in strength development comparable to the control specimens, and (iv) the use of RHA in concrete result in impervious RHA-concrete microstructure to agent of degradation like, sulphate attacks, chloride ingress, etc., as well as good shrinkage properties, and thus produce durable concrete when used. However, some areas such as the bending and shear responses (and allied properties) of reinforced concrete slabs and beams with RHA are presently not yet covered by researchers; they are therefore recommended for future investigation.

Keywords: Cement; Pozzolans; Rice husk ash; Strength; Structural concrete

Contents

* Corresponding author.
E-mail addresses: christopher.fapohunda@fuoye.edu.ng (C. Fapohunda), timboljekbuild@yahoo.com (B. Akinbile), ahmed.shittu.0378@fuoye.edu.ng (A. Shittu).
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1. Introduction

The fact that the contribution of the cement industry to the global emission of greenhouse gases, especially CO_2, is 8–10% (Mehta, 2002 and Sudendro, 2014) and with the added fact that it is the third most energy-intensive industry (Shafigh et al., 2014) raise a serious environmental concern in the built environment. Some measures being taken to decrease the rate of CO_2 emissions during cement manufacture include: (i) attainment of a higher efficiency in the production process, by decreasing fuel consumption and (ii) reduction of the rate of clinker production by using mineral admixture replacements (that is, additions of supplementary cementing materials (SCMs) during manufacture or directly through cement replacement at the building site). Mehta (2002, 2009) however concluded that to obtain a major reduction in the CO_2 emission associated with cement production, the clinker content of the final product must be lowered as much as possible by maximizing the proportion of mineral admixtures in cement, and to increase the use of blended cements in general construction. It has further been shown that if just 30% of cement used globally was replaced with supplementary cementing materials (SCMs), the rise in CO_2 emissions from cement production could be reversed (Ecosmart, 2008). In recent times, anthropogenic wastes, hitherto valueless, and creating disposal problems with potential to pollute the environment, are presently serving as source of SCMs. This has created kind of environmental balance. Many researchers have not only been able to establish that the use of supplementary cementitious materials (also known as pozzolanic materials) like blast furnace slag, silica fume, metakaolin (MK), fly ash (FA) and rice husk ash (RHA) etc. can improve the various properties of concrete, but also can contribute to economy in construction costs (Amrutha et al., 2009). In particular, rice husk (the source of RHA), an agro-based waste material that is abundant in many parts of the world, especially in rice cultivating countries, like Nigeria, is a suitable construction material for sustainable built environment. Each ton of paddy rice can produce approximately 200 kg of rice husk, which on combustion produces about 40 kg of ash (Bui, 2001). The rice market monitor of the Food and Agricultural Organisation (FAO, 2016) put the global rice paddy forecast for 2016 at about 745.5 million tons, and that is approximately 149.1 million tons of rice husks. The suitability of RHA for the production of structural concrete, having been classified as highly reactive pozzolan, is not only considered as "green" and environmental friendly construction material, but also useful in the quest to reduce the cement constituents of concrete production. Thus the use of rice husk ash in concrete in a large scale will help to lessen the adverse effects on the environment from myriad of activities that take place in the domain of construction, by reducing the rate at which cement is being produced. A lot of research efforts that have gone into laying the foundation for further works, probing its properties and behaviours on its: (i) production (Cook, 1986; Sugita, 1992; Bui, 2001), (ii) hydration (Cook et al., 1976; James and Subba, 1986; Hwang and Wu, 1989), (iii) microstructure