Investigation on micronized biomass silica as a sustainable material

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Abstract

Micronized biomass silica (MBS) is an agricultural waste obtained from controlled burning of rice husk and grind in jar mill. This paper investigates the optimum percentage of MBS for the replacement of cement by conducting several experiments with the blended cement paste and mortar with MBS percentages varying from 0, 4, 8 and 12. In addition, hydration products were also investigated in the blended cement paste through X-ray diffraction. Due to the pozzolanic reaction of MBS with cement hydrates, secondary calcium silicate hydrates (CSH) were formed and also MBS which has a potential to reduce the intensity of Ca(OH)₂ exhibited improved properties. The experimental results showed that the optimum percentage of MBS for the replacement of cement was 8% for the materials used in this study. The mechanical and durability properties of recycled aggregate concrete by replacing cement with 8% MBS were also carried out and it was found that the concrete exhibited improved properties. There by, using MBS one can overcome the drawbacks of recycled aggregate concrete as it acts as a supplementary cementitious material. Thus, by combining recycled concrete aggregate with MBS will achieve sustainable development.

1. Introduction

The rapid increase in population and economic development has led to the increase in production of waste products, such as fly ash, GGBS, rice husk ash and silica fume whose disposal is becoming a challenging task. Presently, a number of research studies are being carried over towards the use of waste in the concrete [1–3].

Rice husk is an agricultural waste obtained during the processing of paddy. It constitutes 20% of the 590 million tons of paddy produced in the world [4]. In India the rice husk is considered as a waste and is used for cattle feeding, land filling, manufacturing partition boards etc. [5]. Rice husk ash (RHA) obtained by controlled burning contains high amount of amorphous silica which is used in concrete as mineral admixture [6–8]. This amorphous silica reacts with hydration products and forms more CSH gel. This enhances the mechanical and durability properties of concrete [9]. It is understood that the incorporation of RHA in concrete improves strength, reduces permeability, and gives resistance to corrosion [10]. Various studies also prove that recycled aggregate concrete (RAC) with rice husk exhibits better mechanical properties than those without RHA [11,12].

In the recent times, another common waste product that affects the environment is construction and demolition waste, which is increasing with the rapid growth in urbanization due to demolition of old buildings and constructing high rise buildings. The construction industry in India generates about 12–14.7 million tons of waste annually [13,14]. Of these 2.40–3.67 million tonnes are concrete wastes [15,16]. Since aggregate constitutes 60% to 75% of the concrete volume [17], the use of demolition concrete wastes as recycled concrete aggregate can conserve the environment. The carbon emission for the production and transportation of each ton of recycled aggregate is 0.0024 million tons which is less compared to virgin aggregates reported 0.0046 million tonnes [18]. The net carbon emission at the time of production of virgin aggregates can be reduced by the replacement of recycled aggregates which will give more environmental benefits [19]. Even though recycled aggregate is a good alternative to natural aggregate, there are some drawbacks for structural application.

The physical properties of the recycled aggregates depend on the presence of old mortar in the concrete and the strength of the parent concrete [20]. Higher water absorption is the significant difference between natural aggregate and recycled concrete aggregate concluded by Nixon [21]. Etxeberria et al. [22] reported that there was a strength reduction when natural aggregates are fully replaced by recycled aggregates in the concrete. Kou [23] reported that the recycled aggregate concrete is more permeable compared to the control concrete. Katz [24] observed from his study that the