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Workability and heat of hydration of self-compacting concrete incorporating agro-industrial waste

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ABSTRACT

This paper presents an experimental study on the workability and the heat of hydration in Self-compacting concrete (SCC) incorporating agro-industrial waste and blended aggregates. The control mixture contained only Ordinary Portland Cement (OPC) as the binder while the remaining mixtures incorporated binary and ternary cementitious blends of OPC, palm oil fuel ash (POFA) and fly ash. The replacement of waste was from 10% to 40% by mass of the total cementitious material of the concrete for workability test and limited to 30% and 40% replacement for the heat of evaluation test. Workability i.e. passing ability, filling ability and segregation resistance was determined and semi-adiabatic temperature rise during the initial stage of hydration was measured by thermocouples. It was observed that fly ash mixes required the least amount of super-plasticiser (SP) to obtain a workable SCC, however, POFA mixes had the reverse effect. The ternary use of POFA and fly ash had better workability properties than the POFA mixes and performed the best in terms of segregation resistance. The ternary mixes also had the lowest amount of heat dissipation with peak temperatures occurring earlier than the fly ash mixes. The experimental studies indicate that ternary blend SCC with POFA and fly ash has significant potential when considering a sustainable construction material hence also providing a cleaner production solution for the palm oil industry.

1. Introduction

Concrete is one of the most important elements for any kind of construction work and composed of mainly cement, aggregate, water and chemical admixtures. Generally, concrete is compacted by a vibrator or steel bar after being placed inside the formwork to remove the entrapped air after which it becomes a dense and homogeneous material. Compaction is very important in order to produce a uniform concrete mix with desired strength and durability properties.

Self-compacting concrete (SCC) is an innovative construction material that has been developed in concrete technology. It is competent to flow, filling all areas and corners of the formwork even in the presence of congested reinforcement and compacts under its own weight. SCC requires three fresh concrete properties including filling ability, passing ability and adequate segregation resistance (EFNARC, 2002; PCI, 2003; EGSCC, 2005; and Schutter, 2005).

The main hypothesis for SCC is the reduction of course aggregate and the increase of the cement content to maintain its fresh state properties and homogeneity. High cement content increases overall concrete production cost, generates high heat during the hydration process, and increases creep and shrinkage problems. Thus significant quantities of pozzolanic material including fly ash, rice husk ash, silica fume, granulated glass blast-furnace slag and bagasse ash are used to replace cement in order to improve the fresh state properties, control generation of heat and to reduce creep and shrinkage problems (Sua-Iam and Makul, 2013, 2014; Rahman et al., 2014; Thomas and Gupta, 2013). It is also indirectly beneficial for the environment due to the reduction of carbon dioxide emissions associated with the manufacture of Portland cement clinker (Yang et al., 2014).

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