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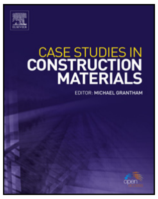

Case study

Case study on production of self compacting concrete using white cement by pass dust

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ABSTRACT

Large quantities of white cement bypass dust (WCBPD) are accumulated annually as a by-product of Jordan white cement manufacturing; representing an environmental threat and a disposal financial burden. The outcome of an experimental study to investigate the potential of using this dust in producing self-compacting concrete (SCC) for structural purposes is reported. SCC mixtures were prepared at a constant water-to-binder ratio of 0.45 using five different replacement percentages of cement by WCBPD ranging from 10 to 25% (by cement weight) with partial replacement of fine limestone aggregate by crushed stone dust. Fresh and hardened properties were investigated to establish the significance of dust use in SCC. The fresh properties of the SCC mixtures were determined by slump flow, V-funnel, and L-Box test. Tests on hardened SCC included compressive strength, internal pore structure in terms of ultrasonic pulse velocity and capillary porosity, dry shrinkage expansion, and durability against alkali-silica reaction. SCC mixes demonstrated acceptable resistance to segregation, with satisfactory passing and filling abilities. Use of WCBPD had significantly contributed to reducing alkali-silica reaction expansions by as high as 44%. The different tests indicated the use of WCBPD at levels below 10% would not undermine strength or durability, maintain acceptable volume stability, and impart improvement to resistance against ASR. Furthermore, the study revealed that concrete for structural application with compressive strengths greater than 40 MPa can be produced at 25% WCBPD replacement of cement by mass.

1. Introduction

Self-compacting concrete (SCC) represents one of the most outstanding advancements in concrete technology in the last three decades. SCC can be placed in reinforced steel congested sections and compacted, without any vibration. Furthermore, SCC can be used to produce durable or fair face concrete with the least labor number during a relatively short construction period in absence of vibration and noise [1–4]. The basic components of SCC are practically the same as those used in conventional concrete; except for the need for fillers in the form of stone powder or pozzolanic additives. Mineral admixture, such as slag, fly ash, oil shale ash, limestone powder, tire rubber, rice husk ash, silica fume, residue of masonry, waste plastic, basalt powder, bagasse ash, lignite-coal fly ash and natural Zeolite, have been used in producing SCC [5–20]. Using mineral

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admixture allowed SCC to have high filling and passing abilities as well as increased its resistance to segregation, also, using mineral admixture in SCC reduce the use of cement in concrete and therefore reduce greenhouse gas emissions and energy consumption [5–8,15].

Silva et al. [5] investigated the behavior of SCC made with recycled coarse aggregate and a mineral admixture obtained from a residue of masonry. The SCC showed a good workability and resistance to segregation, passing ability and filling ability. The mechanical properties were reduced with incorporation of the recycled coarse aggregate due to the poor adhesion between the old mortar and aggregate.

Ranjbar et al. [6] investigated the fresh and hardened properties of SCC with natural Zeolite (NZ). Results showed that with the inclusion of NZ, SCC can be successfully produced with satisfactory performance in flowability, passing ability and viscosity. Regarding to hardened properties, the effect of NZ on the compressive and splitting tensile strength of SCC mixtures is generally related to its W/B ratio. Moreover, compressive strength enhancement was seen for mixes with slump flow higher than 550 mm at prolonged mixing time

Alsubari et al. [15] conducted laboratory investigations to evaluate the use of high-volume treated palm oil fuel ash (T-POFA) in producing economical and eco-friendly self-compacting concrete (SCC).The concrete mixtures were prepared with 0%, 50%, 60% and 70% replacement (by mass) of OPC with T-POFA at a constant water/binder ratio. However, the concrete specimens attained a compressive strength equivalent to that of the control at an age of 28 days and an even higher compressive strength at later ages. The specimens containing high-volume T-POFA have lower drying shrinkage and exhibited better performance against aggressive chemical attack. The results showed that T-POFA can be utilized as a cement replacement up to 70% in SCC to produce low-cost and sustainable concrete.

Given that cement is the most expensive component of concrete, reducing cement content is an economical solution [9]. As these mineral additives replace some of the Portland cement, the cost of SCC is reduced, particularly when mineral additives is an industrial by-product.

White cement bypass dust (WCBPD) is a byproduct of the manufacture of white cement, composed of micron-sized particles collected from the precipitators during the production of the clinker [21]. In Jordan, huge quantities of WCBPD are generated annually from a white cement production plant. WCBPD is considered as an industrial waste material, all of the WCBPD produced in Jordan is disposed of in an on-site landfill. This is because of the difficulty in transporting and storing this industrial byproduct, and a lack of adequate ways for reuse and recycling. Numbers of studies have been conducted to investigate the use of WCBPD in civil engineering applications [21,22]. Using white cement by pass in production of self-compacting concrete will bring positive impact on the environment because it will allows the use of addition from industrial waste and it will solve the problem of disposal this material as a landfill.

The objective of this study is to investigate the possibility of production of SCC using white cement by pass dust. Five SCC mixtures were prepared with 0, 10, 15, 20, and 25% of WCBPD replacement of cement. The experimental investigations were divided in two phases. In the first part, the fresh properties of the SCC mixture will be assessed by several tests such as slump flow, and V-funnel test. Hardened properties will be presented by compressive strength, drying shrinkage, ultrasonic pulse velocity (UPV), capillarity coefficient, and alkali silica reaction.

2. Experimental program

This section presents the physical and chemical properties of the materials used in various mixtures; preparation of SCC specimens, and tests carried out on fresh and hardened properties of SCC. Those included compressive strength, drying shrinkage, capillarity coefficient, alkali silica reaction (ASR) and ultrasonic pulse velocity (UPV).

2.1. Materials

2.1.1. Cement

Ordinary Portland cement produced by local company, which meets the requirement of the European Standards EN 197-1/2000, was used in preparing all the SCC specimens. The chemical composition and the physical properties of the cement used are reported in Table 1.

2.1.2. White cement bypass dust (WCBPD)

The WCBPD was provided by a white cement production plant located in Al-Khaldiya to the north-east of Amman, Jordan. The chemical composition of WCBPD was obtained using X-Ray fluorescence (XRF) with results shown in Table 2.

Table 1
Chemical composition of Ordinary Portland Cement.

Compound	CaO	SiO_2	AL_2O_3	Fe_2O_3	MgO	SO_3	K_2O	Na_2O	LOI	BF	FL
%	61.36	21.5	5	4	2.97	2.3	0.43	0.41	2.06	350	0.81

BF, Fineness by Blaine method in m^2/kg., FL, Free lime %.