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Properties of architectural mortar prepared with recycled glass with different particle sizes

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ABSTRACT

The recycling of glass waste as a source of aggregate for the production of concrete products has attracted increasing interest from the construction industry. However, the use of recycled glass in architectural mortar is still limited. This study attempts to develop a self-compacting based architectural mortar using white cement and 100% recycled blue glass as key ingredients. To improve the aesthetic qualities, a certain minimum quantity of glass cullets of larger particle size must be present. The influence of particle size of the recycled glass on the engineering properties of fresh and hardened architectural mortar is investigated. The experimental results demonstrate that it is feasible to utilize 100% recycled glass as the aggregate for the production of self-compacting based architectural mortar. These products have an average compressive strength of 40 MPa and flexural strength of 6 MPa at 28 days which are appropriate for some architectural and building applications. Also, the overall performances of all the architectural mortars prepared with different particle sizes of glass aggregates are comparable to those of control mortar mix prepared with river sand.

1. Introduction

A large volume of post-consumer beverage glass bottles is being disposed daily worldwide, only a small proportion is either washed for reuse or re-melted to manufacture new glass. In Hong Kong, the majority of waste glass is used once or a few times before being discarded into landfills [1]. According to government surveys, only 1–2% of the waste glass in Hong Kong is recycled. The use of recycled glass as aggregate for the production of concrete blocks has received considerable application interest [2,3]. General results showed that the recycled glass cullet can be used as a replacement for natural aggregate in the production of concrete blocks without compromising its mechanical properties [4]. Indeed, in many cases, the performance is enhanced [5].

There are a number of new applications of recycled waste glass, including the use of glass cullet in granular base/fill and asphalt pavement (Glassphlat) [6]. They have also been widely used as aggregates in cement mortar and concrete mixtures [7,8]. However, most of the previous studies reported that the use of glass as a coarse aggregate has negative effects on bonding, adverse alkali-silica reaction (ASR) and reduction in concrete strength [9]. Thus, most of the recent works have concentrated on milling glass cullet into powder form (glass powder) to replace cement in concrete [10–13]. The implementation has gained wide acceptance due to the innocuous behaviour of ASR in concrete [13]. Furthermore, the use of supplementary cementing materials (SCM) such as fly ash, metakaolin and slag are recommended as partial replacements of cement for mechanical properties enhancement and mitigating ASR expansion [14,15].

Recently, the use of recycled glass cullets (due to their aesthetic properties) to produce decorative concrete has attracted much interest. In order to be aesthetically pleasing and visible, glass particles of a certain minimum size must be present (for example, particle size ranging from 2.36 to 5 mm or 5 to 10 mm is needed). However, the use of glass aggregates of these sizes in concrete is also the most detrimental to the concrete in terms of strength reduction and ASR expansion [16].

This paper investigates the effect of different particle sizes of glass aggregates on the engineering properties of fresh and hardened self-compacting based architectural mortar (SCAM). In addition, the influence of different percentages of metakaolin as partial replacements of white cement in the mortar is also reported.

2. Experimental programme

2.1. Materials

2.1.1. Cement

A white cement (WC) was chosen to be used in this study due to aesthetic considerations for architectural mortar applications. It is

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