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Potential of substituting waste glass in aerated light weight concrete

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Abstract

This paper investigates the potential of substituting the waste glass in making aerated light weight concrete. The physical, chemical and activity index properties of the ground waste glass are first investigated. Subsequently, the waste glass is incorporated in the aerated light weight concrete formulation as cement substitution at different ratios. The density and initial compressive strength of aerated light weight concrete result are then compared. Based on the initial experiment results, the ground waste glass can be potentially substituted up to 20% as pozzolanic material in making aerated light weight concrete.

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Keywords: Waste glass; Aerated light weight concrete; Pozzolanic material; Cement replacement; Sand replacement.

1. Introduction

According to 2014 Singapore National Environment Agency (NEA) annual statistic report, 79,500 tons of waste glass was generated in Singapore and only 20% of the amount was recycled [1]. The remaining quantity of waste glass was either disposed at landfills or recycled back to low cost glass product at the neighboring countries [2]. The deposition of waste glass to landfills is definitely not a sustainable environmental solution to Singapore. Although, the waste glass can be recycled back to new glass products; however, the process of sorting, crushing and re-melting which require high energy is not favourable in long run. Furthermore, these recycling process may also instigate air pollution if there is any mishandling.

Aerated light weight concrete or also known as cellular concrete is a light weight building material that has been aerated to reduce its density before to the setting of Portland cement in the formulation. The LWC offers not only low density, they also possess superior insulation and acoustic performance, fire resistant properties as well as

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relatively high strength coupled with dimensional stability. The LWC can be used to make partitions, prefabricated unit, floating platform and many other applications in building and construction that require low load application. The quick and easy installation of LWC also can significantly reduce the intensive labour and overall load of buildings.

Therefore, the main objective of this study is to investigate the potential of substituting the increasing waste glass number as in the production of aerated light weight concrete (LWC). Furthermore, converting the waste glass into raw materials in building material open up an attractive option in the building and construction industry. The benefits not only reduce the reliance on natural resources, lower the disposal cost and landfill volume but also help to reduce the carbon dioxide emission to our environment [3]. Utilizing industrial by-products such as bottom ash, pulverize fly ash and steel slag as fine aggregate for cement substitute has been common in the building and construction industry [4]. However, there are still very limited studies focusing on the use of waste glass as the replacement raw material in making LWC.

This paper therefore present the preliminary investigation of using finely ground waste glass in making LWC in terms of physical (dry bulk density) and mechanical (compressive strength) as a partial replacement of cement or sand. The LWC sample are water cure by conventional method and the properties are investigated and compared. This research hopes to improve the building and construction industry by increasing the usage of waste glass while sustaining good LWC performance and enhance the waste glass recycling rate. By substituting waste glass in LWC as partial replacement of cement can pose an advancement towards the development of a sustainable environment, energy efficient concrete-based building and construction industry.

2. Materials and experiment

2.1. Materials

The main materials used to produce the LWC samples were Ordinary Portland Cement (OPC) CEM I 42,5N, water, sand, lime, gypsum, ground granulated blast furnace slag (GGBS) and aluminum powder. The waste glass used in this research was a typical clear soda-lime glass that obtained from post-consumer glass product.

2.2. Waste glass

Two types of post-consumer waste glass (colored and non-colored clear type) were used on this study. The post-consumer waste glass was crushed into cullet size and followed by grinding process to fine particles using a Fritsch Planetary Mill PULVERISETTE 5. The glass particles were then sieved into desired particle size range. The ranges of glass particle size used in the experiment were:

- Waste glass having particle size in the range of >90µm
- Waste glass having particle size in the range of 45-75µm

The chemical properties of both color and non-colored clear glass were first compared using X-ray fluorescence (XRF).

2.3. Mixtures

The basic materials used to produce the LWC sample is summarized in Table 1. Milled waste glass, foaming agent (aluminum powder), water, lime, cement, GGBS and gypsum were added at different proportions with varying the ratio. The bulk density of the waste glass and cement are 1051 kg/m^3 and 1522 kg/m^3 respectively. To investigate the potential of replacing the waste glass in making LWC, a specific proportion of waste glass is incorporated in LWC formulation as cement.

Table 1 summarizes the LWC formulations prepared in this paper. The finely grounded waste glass was mixed and casted into 100x100x100mm steel mould based on the formulation in Table 1. Six LWC mould samples were prepared for each formulations. The LWC samples were demolded after 24 hours, the excess expanded portion of the