Journal of Cleaner Production 17 (2009) 1663–1668

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Paving blocks from ceramic tile production waste

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ARTICLE INFO

Article history:
Received 16 March 2009
Received in revised form
11 August 2009
Accepted 16 August 2009
Available online 22 August 2009

Keywords:
Paving blocks
Ceramic tiles
Compressive strength
Portlandite
CSH

ABSTRACT

This paper presents the use of waste mud from ceramic tile production as the main component in paving blocks. Compressive strength values of the blocks were compared with the standard value as prescribed by the Thailand Industrial Standard. The waste mud was first characterized using XRD, XRF, SEM, Laser diffraction particle size analyzer and sieve analysis. Paving blocks were subsequently prepared by mixing the waste mud with Ordinary Portland cement (OPC) and compacted using a hydraulic press. Water was added to the cement–mud mix to assist compaction and to strengthen the blocks by hydration of OPC. Effects of water and cement content, immersion in water, as well as compaction pressure on compressive strength were subsequently studied. Increasing compaction pressure and also immersion in water for 5 min every 24 h were found to enhance densification and thus compressive strength of the test samples. The blocks containing 15 wt% cement required a long curing period of up to 28 days for their compressive strength to reach the standard requirement while the compressive strength of the blocks containing 25–30 wt% cement exceeded the standard requirement after curing for only 7 days.

1. Introduction

Ceramic tiles are important construction materials used in almost all buildings. The production of these tiles normally starts from raw material, grinding and mixing, granulating by spray drying, pressing, firing and/or polishing and glazing. Waste mud, which is the sediment of washed down particles from these manufacturing processes is approximately 2 wt% of the final products. This mud which contains both coarse particles (feldspar, quartz, and ground fired tiles) and fine particles (clay minerals such as kaolinite and mica) is far too impure to be re-used in tile production, so it is normally disposed of as waste in landfills. Elimination of this waste mud has become more and more problematic due to the huge amount of this waste produced each year and the increasing cost of disposal. One way forward to solve this problem is by utilizing this waste for other purposes.

Traditional cement pavers mainly contain Portland cement, and both coarse and fine aggregates. Many research papers have reported on modifications of paver components in order to (i) improve properties of the pavers, (ii) reduce the material cost or (iii) utilize waste materials for sustainable construction. Among these reports, the use of waste or recycled materials in recipes has been the prime interest of many groups [1–3]. For example, the Slag Cement Association (USA) had advertised the incorporation of slag cement in soil pavers used as pavement base material for flexible pavements or as a sub-base for rigid pavements. These soil cements showed low early age strength but high strength at later stages [4]. Poon et al. [5] reported the feasibility of using recycled concrete aggregates in the production of paving blocks. Paving blocks made with recycled concrete aggregate and crushed clay brick were later reported by Poon and Chan [6]. A study by Lavat et al. [7] on using ceramic roof tile waste as a Pozzolanic admixture in the manufacture of blended cements showed that incorporation of 20–30% waste in cement mortar gave strength values in the range of 32–40 MPa.

The aim of our research was to assess the feasibility of blending waste mud from ceramic tile production in manufacturing compressed paving blocks. The waste mud contained both coarse and fine particles so it should be able to replace aggregates traditionally used in cement pavers. Effects of processing parameters upon compressive strength, phase and microstructure were studied. The measured strength values were compared to the standard value requirement prescribed by the Thailand Industrial Standard for pavement bricks coded 827–2531. Such standards require the compressive strength value of at least 35 MPa.

2. Materials and methods

Dry waste mud was collected from different areas in the disposal site. Due to its agglomeration, the mud was hammer milled into a powder prior to mixing. Particle size distribution of

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doi:10.1016/j.jclepro.2009.08.008

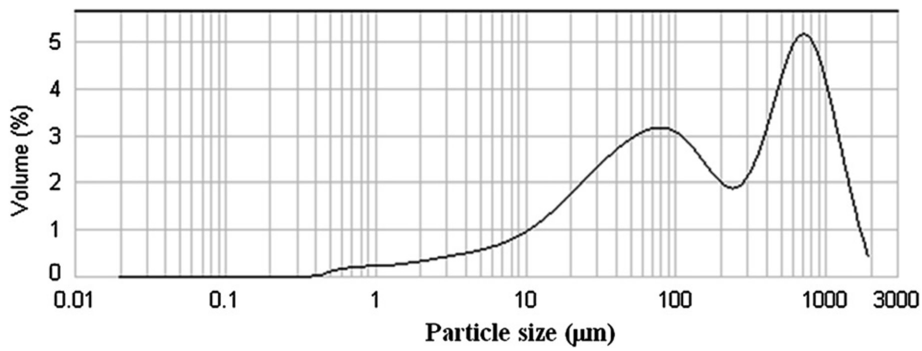

Fig. 1. Particle size distribution of the waste mud after hammer milling into powder.

Table 1
Properties of the waste mud after hammer milling.

Properties	Unit	Value
Particle size range[a]		
-Coarse particles (>325 mesh)	wt %	38
-Fine particles (<325 mesh)	wt %	62
Average particle size	μm	370
Drying shrinkage	%	0.30

[a] Sieve analysis.

the milled mud was measured using a particle size analyzer. Phase analysis of raw materials and cured blocks was performed using an X-ray diffraction while chemical composition was determined using an X-ray fluorescence technique. The mud powder was dried in an oven pre-set at 110 °C for 24 h. Drying shrinkage was determined. Ordinary Portland cement (15–30 wt%) was then thoroughly mixed with the waste powder in a mixer. After mixing to a uniform color, water (15–21 wt% of the cement–mud mix) was added in order to enable compaction and also to hydrate the cement. Water is a common plasticizer

Table 2
Chemical analysis for the dry waste mud and the OPC used in the experiment.

Material	%													
	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	Cr_2O_3	Fe_2O_3	ZnO	ZrO_2	PbO	SO_3	Fe_2O_3
Dry waste mud	2.54	0.74	17.25	71.10	2.94	2.73	0.47	0.06	1.25	0.33	0.54	0.07	–	–
OPC	–	2.06	4.17	20.93	0.67	64.74	0.27	–	–	–	–	–	4.12	3.00

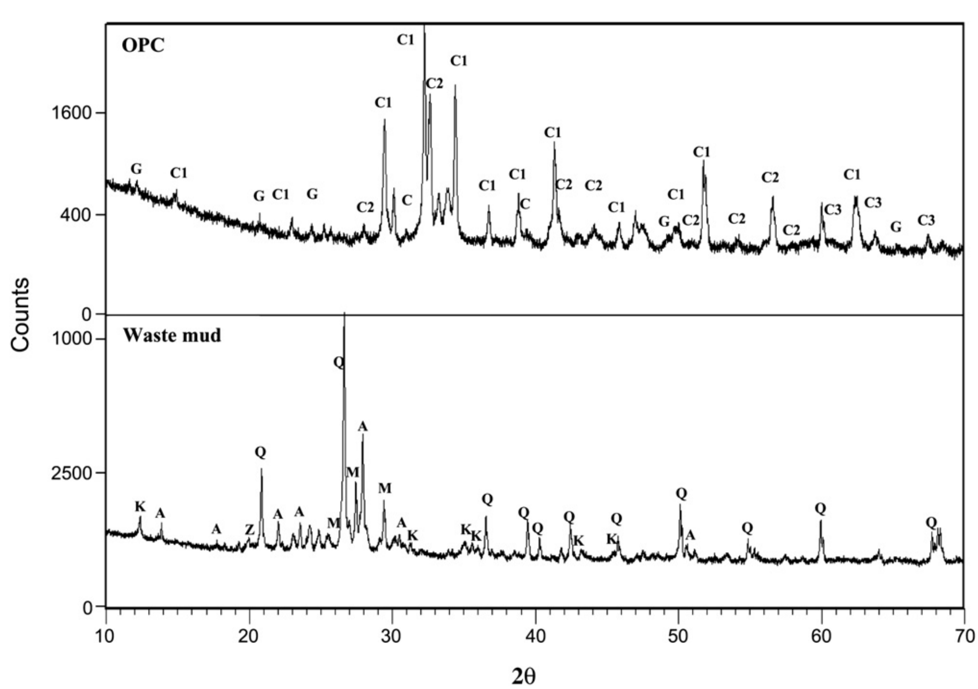

Fig. 2. XRD analysis for the raw materials (A: albite, M: microcline, K: kaolinite, Q: quartz, Z: zircon, C_1: calcium silicate (C_3S), C_2: dicalcium silicate (C_2S), C_3: tricalcium aluminate (C_3A), C = calcium oxide (CaO), G: gypsum).