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Properties of lightweight aggregate produced by rapid sintering of incinerator bottom ash

C.R. Cheeseman*, A. Makinde, S. Bethanis

Centre for Environmental Control and Waste Management, Department of Civil and Environmental Engineering, Imperial College of Science, Technology and Medicine, London, SW7 2BU, UK

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Abstract

The fraction of municipal solid waste incinerator bottom ash with a particle size less than 8mm has been milled, formed into pellets and rapidly sintered in a rotary furnace at temperatures between 900 and 1080 °C. The effect of sintering temperature on density, water absorption and crushing strength has been determined. Sintering at temperatures between 1000 and 1050 °C produces pellets with physical properties comparable to Lytag, a commercially available lightweight aggregate manufactured from sintered pulverised fuel ash. Major crystalline phases present in milled bottom ash were quartz (SiO_2) and calcite ($CaCO_3$), while sintered pellets contained diopside ($CaMgSi_2O_6$), wollastonite ($CaSiO_3$) and clinoenstatite ($Mg_2Si_2O_6$). Leaching of heavy metals from sintered bottom ash pellets in water and under acid conditions (leachate pH 2–7) has been investigated. Rapid sintering at relatively low temperatures significantly reduced leaching in water compared to milled ash. Pb and Zn are leached under aggressive acid conditions (leachate pH 3) with 30–40% of the total present available for leaching. The results indicate that relatively simple processing of the finer fraction of incinerator bottom ash allows this problematic waste to be manufactured into lightweight aggregate with potential uses in a range of construction products and geotechnical applications. Current economic drivers for this in the UK are discussed.

Keywords: Resource recovery; Lightweight aggregate; Sintering; Waste reuse; Incinerator bottom ash; Waste management; Incineration

* Corresponding author. Tel.: +44 207 594 5971; fax: +44 207 823 8401.
E-mail address: c.cheeseman@ic.ac.uk (C.R. Cheeseman).

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1. Introduction

The role of waste incineration is expected to increase in the UK and many other countries where the population density is high and availability of landfill is limited. Although incineration in modern energy from waste (EfW) plants reduces the volume of municipal solid waste (MSW) by up to 90%, this still produces significant quantities of incinerator bottom ash (IBA). The UK Environment Agency recently reviewed the fate of IBA produced by EfW plants in England and Wales. The 11 plants operating between 1996 and 2000 processed 8% of approximately 27.6 million tonnes of MSW generated each year, and this resulted in 642,088 tonnes of IBA in 2000. Seventy nine percent of this was sent direct to landfill, while the remainder was processed prior to use as bulk fill in applications such as embankments or as a substitute normal weight aggregate in asphalt (UK Environment Agency Report, 2002).

Solid waste management in industrialised countries increasingly aims to reduce the amount of waste requiring landfill, by developing viable reuse applications so that wastes are beneficially used as resources (Chang et al., 1999; Woolley et al., 2001). IBA is a heterogeneous mix of ceramic materials such as brick, stone, glass, ferrous and non-ferrous metals and other non-combustible inorganic and residual organic matter (Chimenos et al., 1999; Wiles, 1996; Zevenbergen et al., 1994). Given the possible increasing reliance on waste incineration, developing new, higher value reuse applications for this material is an important research area. In particular, as cities such as London and SE England continue to develop there is an enormous requirement for construction materials. Beneficial reuse of wastes in construction replaces materials that would otherwise need to be extracted from the environment and this has associated sustainability benefits. In addition, key drivers such as the increasing costs of waste disposal and extraction of natural aggregates are making processing wastes such as IBA into new construction products potentially viable.

2. Lightweight aggregate production from IBA

The production of lightweight aggregate (LWA) represents a particularly attractive reuse application for IBA (Owens and Newman, 1999a, 1999b). Most natural aggregates have particle densities of 2.4–2.8 g cm^{-3}, typically 2.6 g cm^{-3}, while LWA have particle densities of 0.8–2.0 g cm^{-3}. As a result, LWA are used for the production of lightweight concrete, lightweight blocks and other lightweight construction products and have additional benefits associated with low density such as high insulation and high thermal inertia. They are also increasingly used in a number of other applications including lightweight geotechnical fill, insulation products, soil engineering, hydro-culture, drainage, roof gardens and filters.

There are many different lightweight aggregates currently available. These can be either naturally occurring low-density materials such as pumice, scoria, volcanic cinders or diatomite or they can be manufactured by thermally treating expanding clays, shale, siliceous rock or slate, such as Liapor, Optiroc, Buildex, Stalite, Haydite, Perlite, Norlite and Solite. There are also LWA manufactured from industrial by-products such as fly ash and paper mill sludge, fly ash, sewage sludge and clay, and expanded blast furnace slag. Lytag is the