Chapter 14
Reusability of Ashes for the Building Sector to Strengthen the Sustainability of Waste Management

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ABSTRACT

Coal, as a fossil fuel, is used to generate power for industrial operation. Two types of industrial ash, including fly and bottom ash, which are solid residues arising from coal burning, are dumped to the landfill with no care for reuse. These wastes consist of environmental issues needing to be resolved. The ashes are used in the production of cement, concrete, aggregates, adobe, brick, and insulation material, in the construction of dam and road, and in geotechnical applications. Construction material is a form of cementitious materials based on ash as source material and it is an environmentally friendly choice against Portland cement releasing a large amount of greenhouse gas to the atmosphere during energy intensive manufacturing process. It is a good alternative to the solution of environmental problems based on the waste ashes in the international scale. In addition to its economic benefits, it is suitable for industrial symbiosis. This chapter explores the reusability of ashes for the building sector to strengthen the sustainability of waste management.

INTRODUCTION

In industrial applications, the process of raw material and production is based on a single support; and waste generations in most industrial organizations are an inevitable result. Coal, as a fossil fuel, is used to generate power for industrial operation. Two types of industrial ash, including fly and bottom ash, which

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are solid residues arising from coal burning, are dumped to the landfill with no care for reuse. These wastes consist of environmental and technical issues needing to be resolved. Depositing or disposal of these wastes leads to significant environmental pollution. Some environmental problems of the ashes are dust, damaging agricultural products, rain and wind erosion, radiation and infiltration of toxic substances in soil. Therefore, environmentally undesirable results occur concerning agricultural products, water and air quality, wildlife and the region's economic status (Doğan-Sağlamtimur *et al*., 2016).

Using ashes in various areas and gaining them to the country's economy seem to be possible, if solutions to these problems are found. Due to their fine formation, pozzolan property and the one-dimensional spherical structure, the ashes are resistant to freezing and thawing and is preferred as building material. Therefore, construction industry mainly comes first among the sectors using the ashes. The ashes are used in the production of cement, concrete, aggregates, adobe, brick, gas concrete and insulation material; in the construction of dam and road, and in geotechnical applications. The production of cement is one of the areas most commonly used in the construction industry due to cost reduction, energy conservation, and environmentally friendly behaviour. The ashes are used as additive and substitute material in both normal and lightweight concrete as well as in ready-mixed concrete whose use is increasingly getting widespread in the production of pre-production and pre-stressed concrete elements, as a water trapping additive in concrete.

Concrete usage around the world is second only to water and Ordinary Portland Cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are too many. The cement industry is held responsible for some of the CO_2 emissions. The amount of the CO_2 released during the manufacturing of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of 1 ton for every ton of OPC produced (Motorwala *et al*., 2013).

OPC is by far the most commonly used binder in construction practices. For a long time, OPC concrete was considered to be very durable material requiring a little or no maintenance. Unfortunately, its resistance to chemical attacks such as acids and sulphates is of concern. In the case of acid attack on OPC concrete, calcium salts of the attacking acid rapidly form; and the concrete loses its strength and deteriorates quickly. Acid attack has not traditionally attracted much attention, even when cement composites are severely damaged by acids wherein calcium hydroxide is dissolved and the hydrated silicate and aluminium phases are decomposed (Thokchom *et al*., 2009).

The demand for OPC is increasing day by day; and hence, efforts are being made in the construction industry to address this by utilising supplementary materials and developing alternative binders in concrete. The application of geopolymer technology is one such alternative. The abundant availability of fly ash worldwide creates opportunity to utilise this by-product of burning coal, as a substitute for OPC to manufacture concrete. When used as a partial replacement of OPC, in the presence of water and in ambient temperature, fly ash reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate (C- S-H) gel (Motorwala *et al*., 2013).

Green engineering construction material is a form of cementitious materials based on ash as source material; and it is an environmentally friendly choice against OPC releasing a large amount of greenhouse gas to the atmosphere during energy intensive manufacturing process. It exhibits many excellent properties such as high compressive strength, low creep, good acid resistance and low shrinkage.

In terms of environmental technologies, in the pyramid of waste management hierarchy, conversion of waste to another product is named as reuse. Each year very large quantities of ashes are released as waste from power plants and various industrial organizations during coal burning. Therefore, develop-