Chapter 24
Sustainable Construction Materials

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ABSTRACT

Due to ever increasing demand for the conventional construction materials as well as an increase in agro-industrial by-products it is essential to reuse these materials. As a smart city solution this chapter briefs an overview for the application of alternate raw materials as a principal source for the development of sustainable construction materials. The potential application of the discussed raw materials is elaborated as cementitious material, the aggregates as well as alternative reinforcement material. To understand the process of application, sustainable masonry product development is discussed in detail. In order to evaluate the feasibility of the raw material, the necessary physico-chemical test evaluation methods are also briefed. The developed end product performance evaluation is also discussed by desired tests as recommended by standards. The chapter concludes with a positive note that reuse of agro-industrial by-products is a feasible solution for the smart city development.

INTRODUCTION

Globally, due to the rapid urbanization, industrialization and increasing population, there’s a large demand for the building materials over a few decades. That resulted in a chronic shortage of building construction materials. The manufacturing of these conventional building materials consumes a lot of thermal and electrical energy which in-turn pollutes air, water and land. The world’s total cement production has increased from (rounded) 4.08 x10⁴ to 4.18 x10⁴ thousand metric tons during the year 2013-2014 (U.S. Geological Survey, 2015). The number of bricks produced in the UK during the first quarter of
2015 is 464 million bricks (provisional), a rise of 22 million bricks or 5% from the same period in 2014 (Brick Development Association). While the global market for construction aggregates is expected to increase 5.2% per year through 2015 to 48.3 billion metric tons (Concrete construction, 2015). The solid waste generation worldwide is 1.86 billion tons (Waste Atlas Report, 2013). According to the report (2013) of the American Coal Ash Association, the total production of coal combustion process (fly ash, bottom ash, boiler slag, gypsum, etc.) is 114 million tons, while the utilization of the applications like concrete/concrete products/grout, blended cement/feed for clinker, structural fills/embankments etc. is 51 million tons, which is around 55% of the total production. Disposal of solid waste generated from agricultural and industrial production activity is another serious problem. The accumulation of these by-products is not only a burden to the industry, but also affects the environment adversely. In many countries, due to the increasing cost of raw materials and the continuous reduction of natural resources, the use of agro-industrial by-products as a potential alternative construction material is practiced in the construction industry. Industrial by-product, when properly processed, has shown to be selected as construction materials and readily meet the design specifications. In the countries where abundant agricultural and industrial by-products are discharged, these by-products can be used as potential material or replacement material in the construction industry. This will have the double advantage of reduction in the cost of construction material and also as a means of disposing by-products. In view of the utilization of agro-industrial by-products for developing sustainable construction material, the present study reviewed various by-products that were added as a principal raw material to develop the sustainable end products and also relevant tests.

BACKGROUND

Natural resources that are being used especially in process industries leave a by-product called industrial by-products. It normally includes ash and slag coming out of boilers. To manage this generated by-products which normally go for land-filling needs additional resources like transportation of these materials as well as a piece of land. The global industrial by-product management market is segmented on the basis of their services (collection, recycling, incineration, and landfill) and further on the basis of regions (Asia-Pacific, Europe, Middle East & Africa, and America). It is expected that the by-products generation in a 5-year span may get doubled with the current practices of production industry. The aspiring countries under rapid development are also eying for better and better infrastructure which is also putting a lot of pressure on conventional construction material manufacturers (cement, bricks, concrete, steel, etc.). In the era of smart city development to manage the supply of the end products and also to have the free access to piece of land it is projected to reuse the potential by-products for the development of sustainable construction materials. The present chapter shall briefly discuss the design procedure for sustainable material development, especially where raw materials can be used as partial or full substitute of cement or fine aggregates.

RESEARCH STATEMENT AND METHODOLOGY

The solid waste generated by industrial activity (e.g. Boiler ash) is generally dumped. However, if local manufacturers like cement, bricks, ready mix concrete plant, etc. are aware about the application and