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Review

Experimental characterization of sugarcane biomass ash – A review

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HIGHLIGHTS

- The process of development of pozzolanic binder from sugarcane crop is proposed through a framework.
- Physico-chemical characterization, pozzolanic reactivity, and the rheological performance of sugarcane biomass ash are analyzed.
- Physico-mechanical and the durability properties of blended concrete are reviewed extensively.
- The factors responsible for the pozzolanic reactivity of the sugarcane biomass ash are studied.
- The application of sugarcane biomass ash into the concrete provides solution to the rapid depletion of natural resources.

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ABSTRACT

The present paper reviews the experimental characterization of sugarcane biomass ash as a pozzolanic binder for producing sustainable concrete. The process of development of pozzolanic binder from sugarcane crop is proposed through a framework. The effect of combustion temperature and grinding conditions on the pozzolanic property of sugarcane biomass ash is discussed. The physico-chemical characterization, pozzolanic reactivity, a heat of hydration, and rheological performance of sugarcane biomass ash are studied. Furthermore, the water absorption, sorptivity, water consistency, compressive strength, flexural strength, split tensile strength, modulus of elasticity, chloride penetration, chloride diffusion, and soundness properties of the concrete are analyzed for the different replacement percentage of cement. Reasonably, 25% replacement level of cement by sugarcane biomass ash in producing sustainable blended concrete is considered as an optimum replacement. It gives satisfactory results of physico-mechanical, durability, and strength properties of blended concrete. The present paper explores various factors responsible for the optimum replacement level of sugarcane biomass ash in the concrete such as growing conditions of sugarcane crop (including regions), combustion conditions and cooling duration of sugarcane biomass ash, ash collection methods, and grinding conditions of ash.

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1. Introduction

In India, solid waste management is currently a burning issue that demands attention. Around 4.4 billion tonnes of solid wastes generate yearly, only in Asia. However, in India, agricultural sector alone has generated about 600 million tonnes of biomass waste [1]. Currently, in India, around 960 million tonnes of residual solid waste have been generated from the agricultural, mining, industrial, and municipal processes yearly. About 91.162 million tonnes of sugarcane biomass wastes generate yearly [2]. Industrial processing of raw sugarcane crop to obtain edible products (i.e. sugar, jaggery), leaves the residual biomass waste (i.e. bagasse) as a by-product. This accumulated residual biomass waste is used in the boilers as a biofuel for the various industrial operations [3,4]. The biomass combustion process leaves its ash as a by-product. Around 44,000 tonnes of sugarcane biomass ash (SCBA) generated in India per day [5]. The land application of SCBA impacts negatively on the environment, as it pollutes the soil and groundwater. Secondly, the land disposal costs are also rising because of the increasing rate of biomass ash generation. Therefore, a proper technique should be applied to solve the disposal issues of biomass ashes. The combustion of biomass does not have any contribution to the CO_2 emissions into the environment because it undergoes the cogeneration neutralization reaction. This reaction means the amount of CO_2 liberated by the biomass is nearly same as that of it consumed during its plant growth. Therefore, the liberated CO_2 neutralizes with the consumed amount of CO_2 [4,6–7]. Fig. 1 explains the complete framework of the generation of biomass ashes from its agricultural sources. Horizontal arrows indicate the process, whereas vertical arrows indicate the waste generated by the respective process. Due to the higher rate of infrastructure development, the requirement of concrete is also increasing proportionately. The high demand for concrete is further increasing the consumption of their ingredients such as cement, sand, and aggregates. Cement industry plays an important role in environmental pollution because of its CO_2 emissions [8]. Therefore, it becomes essential to find out the substitutes for cement. The present paper reviews the physico-chemical characteristics and the pozzolanic behavior of SCBA. Its application as a pozzolanic binder in concrete is also reviewed in this paper. The findings of the literature study give an effective solution to the SCBA waste management without negatively affecting the environment. It also helps to fulfill the increasing demands of the construction industry in a cost-effective and sustainable way.

2. Pozzolanic properties of sugarcane biomass ash

The pozzolanic behavior of SCBA greatly depends on their physical properties and its chemical compositions. The controlling parameters responsible for the pozzolanic properties are namely, crop species and its growing conditions, including regions, combustion temperature and its duration, cooling duration, ash collection methods, and grinding conditions [9–12].

2.1. Physical properties

Physical properties of the biomass ash cover the particle size, specific gravity, density, pH, strength activity index, pozzolanic index, and microscopy analysis. For using sugarcane biomass ash

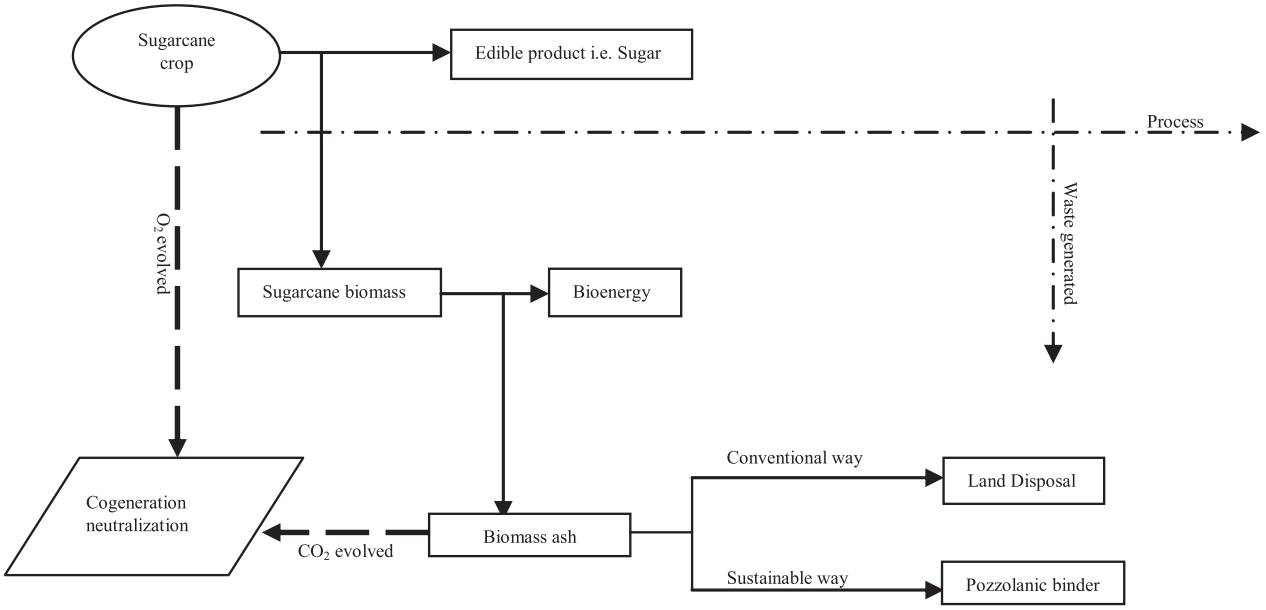

Fig. 1. Process of development of pozzolanic binder from sugarcane crop.