Application of Agro-waste for the Development of Sustainable Construction Material

This innovation tackles three major challenges often faced by developing countries: a shortage of conventional construction materials due to limited availability of natural resources; the pollution from energy-intensive production of building materials and the accumulation of unmanaged agricultural waste. Turning these three problems into an opportunity, experiments were carried out to discover whether sugarcane bagasse ash (SBA) could be the main raw material for a new type of energy efficient and sustainable brick. Bagasse ash is a fibrous by-product that arises after sugarcane stalks are crushed. It is also used as a biofuel. Raw lime, which is a lower-embodied energy binder, was used as a replacement for cement in the development of this innovative and sustainable masonry product. The research focused on mixing different proportions of sugarcane bagasse ash, quarry dust (QD) and lime (L) to create the optimum product, known as SBA-QD-L Brick. The resulting SBA-QD-L building block is lightweight, energy-efficient and sustainable that meets Indian Standards.The developed product as uses by-product is also a cost effective. The further product enhancement with similar ingredient was used to develop the cellular light weight bricks which were further physically implemented in Nagpur, Maharashtra, India. The identified bagasse as was also found useful as an ingredient for mortar and concrete preparation.

Table 1: Design Development Methodology

Nos	Methodology	Approach
1	Data Collection	Online and physical survey for assessing availability of agro-waste (SBA)
2	Characterization of Identified Raw Material	Particle size distribution, X-ray Fluorescence, Scanning electron microscopy, X-ray diffraction and Thermo-gravimetric analysis
3	Mix Proportioning	Iterative procedure for optimum mix proportion with an objective to achieve lighter density, low embodied energy and low cost building blocks and cementitious product.
4	Product Performance Test	Physico-mechanical (Dimension, water absorption, compressive strength, density, flexural strength, combined compressive strength, shear bond &flexural bond strength test), Functional (Thermal Conductivity, Specific heat capacity, equivalent energy), Durability (Chloride, Sulphate and Effect of carbonation), and Environmental (Toxicity Characteristics of Leaching Protocol (TCLP)) Properties
5	Model House Development	Overall performance for indoor temperature evaluation. Experimental model for demonstration and cost economics evaluation

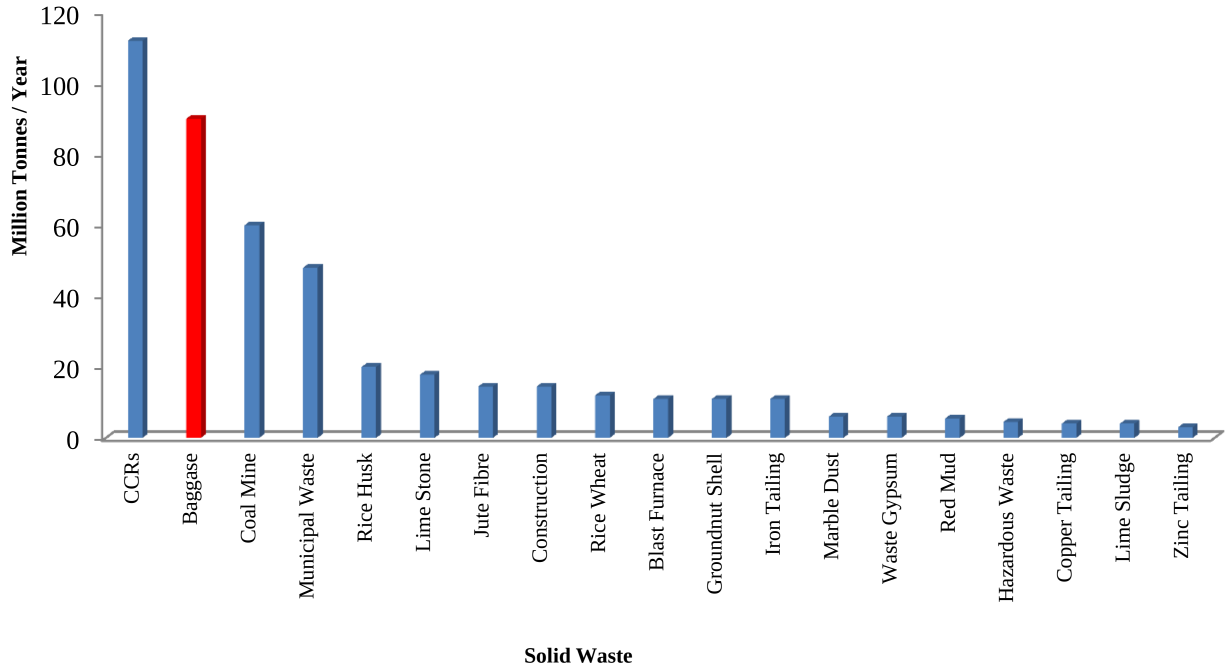

Figure 1: Annual solid waste production in India

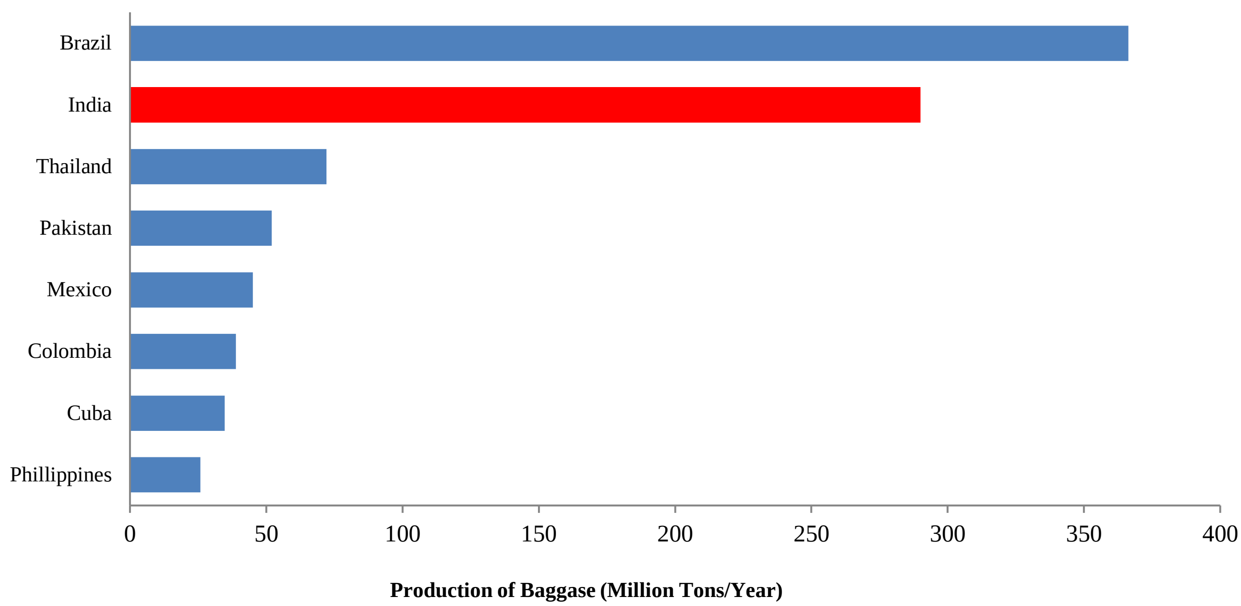

Figure 2: Production of bagasse – Global scenario

Figure 3: SBA-QD-L brick manufacturing at automated brick plant

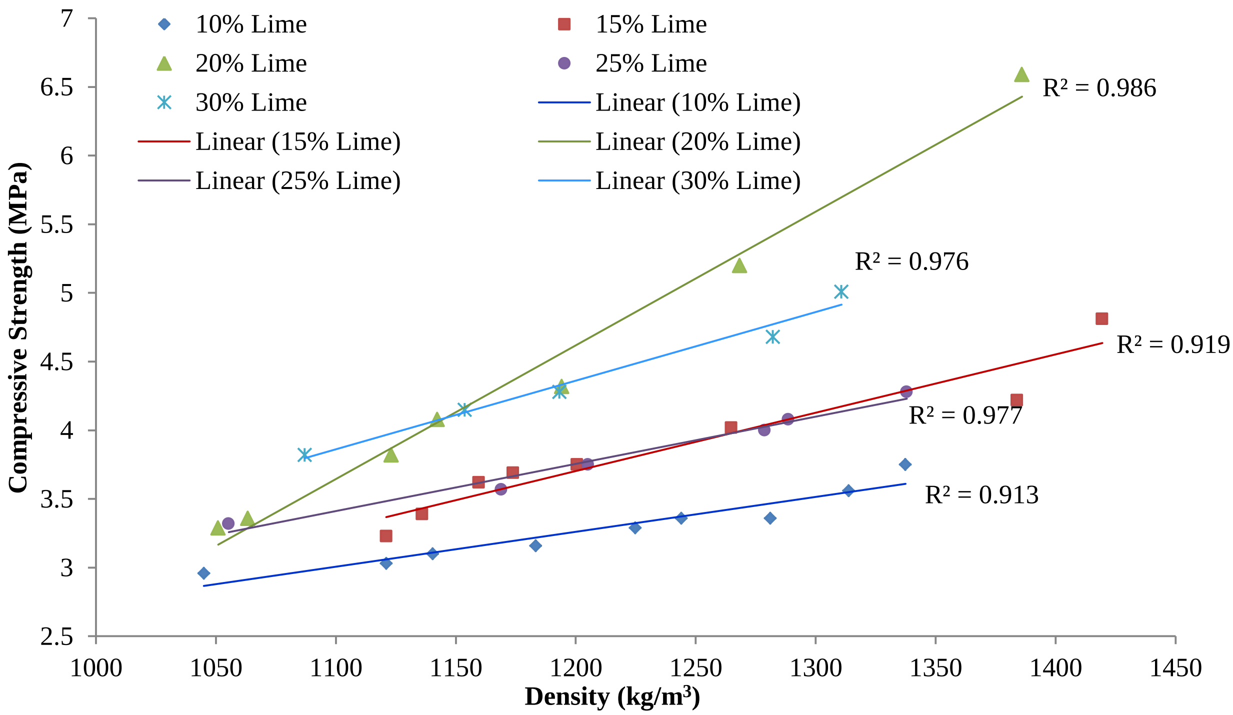

Figure 4: Variation of compressive strength with respect to density of SBA bricks

Table 2: Comparative analysis SBA-QD-L brick Vs Burnt Clay, Fly Ash-Cement bricks

Type of Brick	Weight (kg)	Density (kg/m3)	Compressive Strength (MPa)	Water Absorption (%)	Thermal Conductivity (W/ m K)	Energy/1000 bricks (GJ)	Flexural Strength(kg/m^2)	Shear Bond Strength (kg/m^2)	Flexural bond test (kg/m2)
Burnt Clay	3.250	1600	3.50	20	1.25	4.250	60.82 X 10^{-4}	3.18 X 10-4	1.04 X 10-4
Fly Ash	3.640	1800	6.50	12	1.05	2.366	81.85 X 10^{-4}	3.24 X 10-4	1.34 X 10-4
SBA-QD-L (Mix 24)	2.852	1409	6.59	19.70	0.480	2.282	72.18 X 10^{-4}	3.59 X 10-4	2.54 X 10-4

SBA-QD-L brick sample

Burnt clay brick sample

Figure 5: Photographs of shear bond test

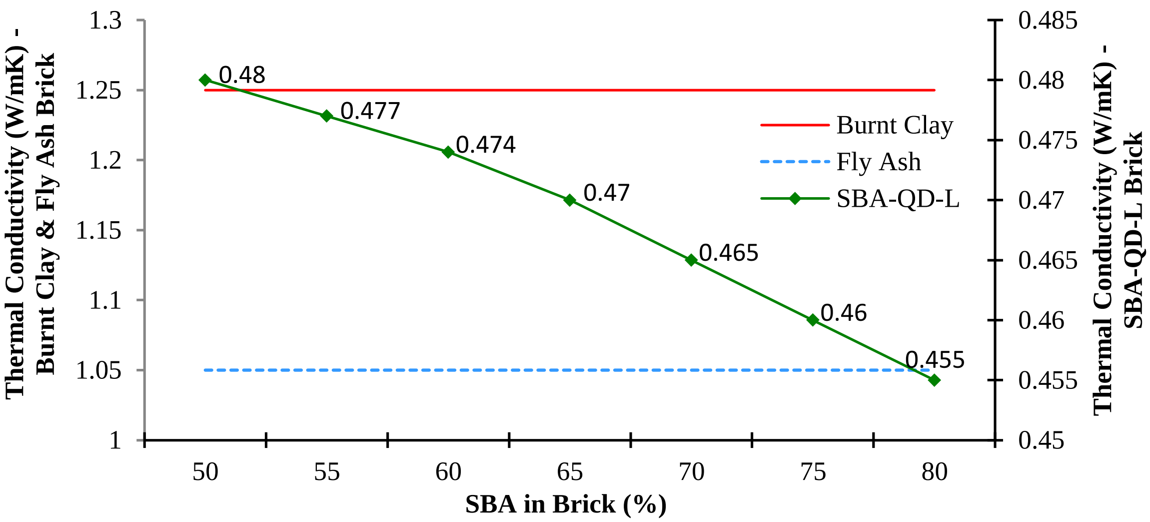

Figure 6: Variation of Thermal Conductivity of SBA-QD-L Brick Vs Fly Ash and Burnt Clay Brick

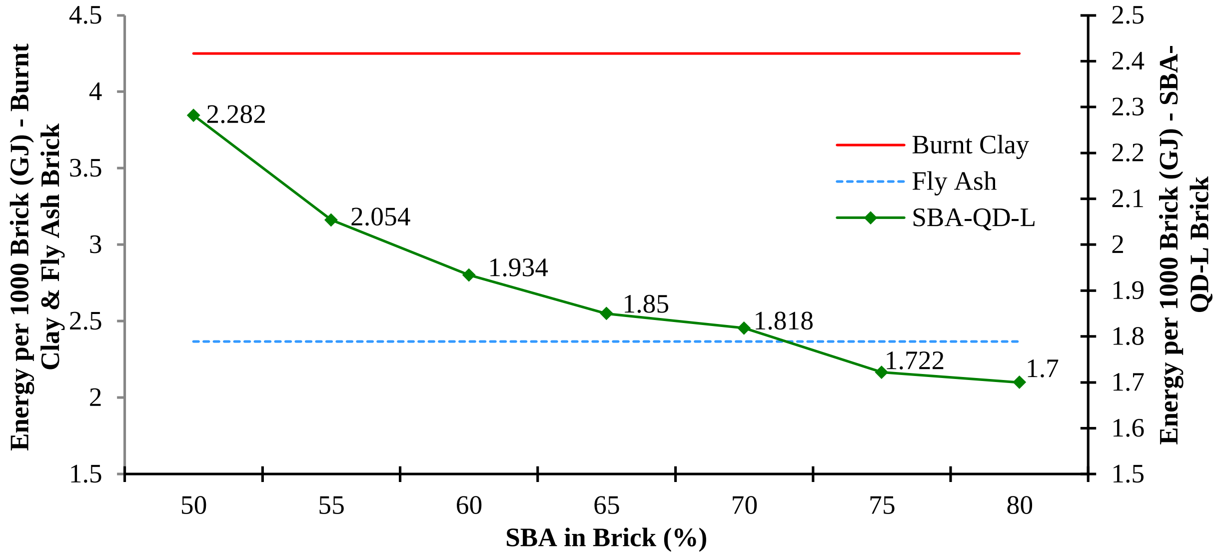

Figure 7: Variation of equivalent energy per 1000 bricks with respect to % SBA in Bricks

Table 3: Nomenclature of model houses

Name of model house	Bricks/Material used
M-1	Sugarcane bagasse ash bricks
M-2	Fly ash bricks

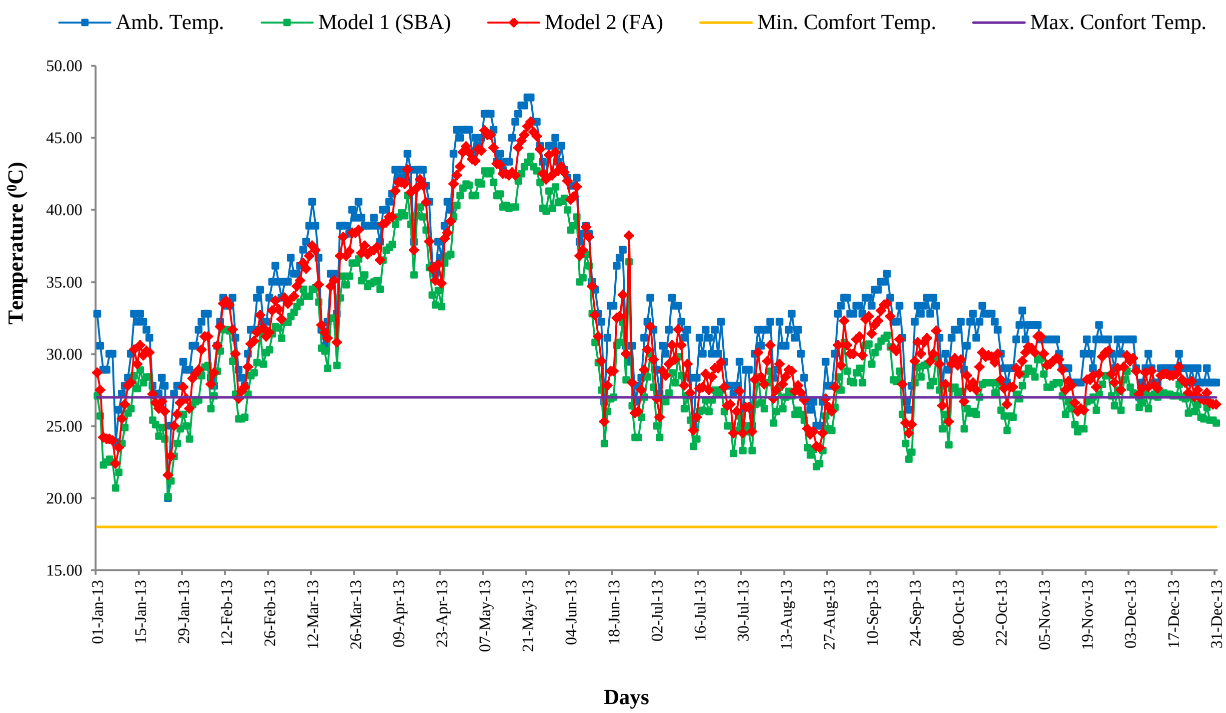

Figure 8: Temperature variation over a year (January 01, 2013 – December 31, 2013)

Table 5: Physico-mechanical Properties Cellular Light Weight Sugarcane Bagasse Bricks

Brick type (Size in mm^3)	Dry density (kg/m^3)	Compressive strength (MPa)	Water absorption (%)	Drying shrinkage	Thermal conductivity (W/mK)
IS 2185 (4): 2008 requirement	1000	3.5	12.5	-	0.36
CLW-SBA bricks (300 X 150 X 100)	1000	3.58	12	No Shrinkage	0.35