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SUGAR MILL WASTE IN CONSTRUCTION

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Abstract: In India, bricks are usually made up of clay, and are generally produced in traditional, unorganized small-scale industries. Brick making consumes larger amount of clay which leads to top soil removal and land degradation. To avoid all this environmental threat an attempt was made to study the behavior of bricks manufactured using, waste materials from sugarcane industrial waste. Recycling of such waste as raw material alternatives may contribute in the exhaustion of the natural resources and reduction in waste disposal costs. In this project we choose sugarcane bagasse ash (SBA) and press mud in ordinary Portland cement (OPC) stabilized bricks. The brick was manufactured of size 25cm x 12cm x 6.5cm. The blocks were named as 4, 6 and 8 then it is added with SBA and press mud by weight of dry soil, then the bricks followed by curing f or period of 28 days. The test like compressive strength, water absorption test, shape and size test in accordance with Bureau of Indian Standards (BIS) specifications by also considering the cost.

There is a strong demand for environmentally safe reuse and effective disposal method for bagasse ash and press mud due to the increasing amount of sludge generated by the various industries or plant in India. Landfills are commonly us ed for disposal of sludge in India; rapid urbanization has made it increasingly difficult to find suitable landfill sites. Therefore, incineration has become one of the few alternatives available for disposal of sludge. The ultimate disposal of incinerated bagasse ash and press mud can be accomplished by using it an engineering construction material. One possible solution for the management of this sludge is to re-use it as a building material, namely, to incorporate this bagasse ash and press mud into bricks. The fired clay brick is one of the most common and abundant masonry building materials and remain popular for its many characteristic properties. As such, the recycling of waste materials by incorporating them into bricks has been a popular topic of investigation over the last century, with varying degrees of success across a wide range of waste material. This popularity is likely due to flexibility on the type of wastes which can be mixed in to the brick making material, but more importantly, the high temperature involved in firing the bricks allows for the volatilization of dangerous Component, as well as the fixation of wastes into the vitreous phase of the brick. The current study investigates the potential for reusing sugarcane sludge or bagasse ash and press mud by using it as a partial replacement material.

***Index Terms* – Sugarcane Bagasse Ash, Molasses, Press Mud, Styrofoam.**

I. INTRODUCTION

In the sugar industry, sugarcane mills generate their own energy required for cogeneration of the steam and electricity in boilers to concentrate, purify, and crystallize the sugar syrup. This source of energy comes from shredded sugarcane bagasse when the sugar juice has been separated by the crushing rollers. It has been mentioned in the literature that almost 270 kg of wet bagasse can be yielded from every ton of sugarcane crush (Jagadesh et al. 2018). In addition, every ton of dried crushed sugarcane is able to generate 62 kg sugarcane bagasse ash (SBA) if burns at a temperature between 300-600°C in evaporators (Jagadesh et al. 2018; Srinivasan and Sathiya 2010). However, the combustion process has some contributions to carbon emission into the environment, the released carbon already has been neutralized by carbon consumed during sugarcane plant growth, and this is an environmentally-friendly industry in general (Jagadesh et al. 2018; Aprianti et al. 2015).

This is widely accepted in the literature that production and application of the nonenvironmentally friendly materials such as ordinary Portland cement (OPC) and/or lime is along with some deficiencies and the negative impacts on the environments. For instance, some toxic elements generate along with production of the lime, or application of the lime above a certain extend causes a reduction in plasticity and increase in fragility and a rapid loss of strength at the failure (EPA 2004; Sabry et al. 1996). On the other hand, production of OPC is the second largest industry in emission of carbon. For instance, it has been reported that one ton of carbon is liberated into the atmosphere when one ton of OPC produces which is about 8% of the total carbon emission into the atmosphere (Jagadesh et al. 2018; Yu et al. 1999). Furthermore, 1.6 tons of natural resources consume for production of one ton of cement. (Jagadesh et al. 2015). As such, partially replacement of SBA with these non-environmentally friendly binders (i.e., OPC, lime, etc.) is a way to reduce the carbon emission into the environment while keeping or even improving their positive role. Many previous studies conducted to investigate effect of substitution of by-products with non-environmentally friendly materials (Chegenizadeh et al. 2018; Keramatikerman et al. 2017; 2016; Vakili et al. 2016).

SBA should safely and carefully transport from the site as this can cause a respiratory illness known as bagassiosis if inhaled (Osinubi et al. 2009). In addition, when the SBA disposes in a bulk amount, it decays and may cause a safety issue. Therefore, handling SBA should be performed along with considering safety principles (Osinubi et al. 2009).

II. MOTIVATION

i. As we all know that the waste eliminated from industries is very harmful for the environment as well as human health.
ii. The residue which remains after crushing of sugarcane and extraction of juice known as 'Bagasse', is one of the largest agricultural residues in the world. However, the residues are used as biomass fuel for boilers in most of cases, but after burning the byproduct left is of no use and generally it is disposed into water bodies which leads to pollution and has adverse effects on environment as well as human health.
iii. So, this really motivated us that why not study that how we can dispose this byproduct in a useful manner. So, there we decided we'll use sugar mill waste ash in brick making. Use of sugar mill waste in bricks can save polluting the environment and produce a greener brick for construction.

III. PROBLEM STATEMENT

i. India has humorous sugarcane industries which eliminates vast amount of sugar mill waste which many times disposed in the form of ash directly.
ii. Many times, clay bricks and other construction materials can be little economical & bad for environment.
iii. Sometimes disposing of waste Can be big question. Many times, it is directly burned and hazardous ash disposed directly into water sources, which causes environmental pollution.

By considering above problems, sugar mill waste which one of the large producing waste can be recycled and can be used in construction, which can reduce environment threats and problems of disposal of waste. Also, by using this, we can bring new change in construction industry and solve environmental issues.

IV. OBJECTIVES

i. To promote the solid waste from the sugar mills as a useful product.
ii. To manage the disposal of waste product into construction raw material.
iii. To dispose the waste safely.
iv. To encourage the waste products as eco-friendly material.
v. To make the bricks which are energy efficient which is the only viable solution to the environmental concerns and natural resources conservation for future generations.

V. LITERATURE SURVEY

As we all know that the waste from the industries is very h armful for the environment as well as to our health, if not disposed in proper manner. The fibrous residue of sugarcane after crushing and extraction of its juice, known as **"bagasse"** is one of the largest agriculture residues in the world. The bagasse is however used as a biomass fuel for boilers, but after burning the by-product left is of no use and generally disposed into the rivers which affect the health of human being, environment, fertile land, sources of water bodies etc. Depending on the incinerating conditions, the resulting sugarcane bagasse ash (SCBA) may contain high levels of SiO_2 and Al_2O_3.Uses of Sugarcane bagasse ash waste in brick can save the sugarcane industry disposal costs and produce a 'greener' brick for construction. Indian sugarcane crop cultivation forms an important part of the Indian agricultural economy. Production of sugar has shown a phenomenal increase in the last 65 years. One of the byproducts of sugar industry is press mud, a solid residue, obtained from sugarcane juice before crystallization of sugar. Generally, press mud is used as manure in India. The aim of the present investigation is to recover protein, sugar and wax from press mud. The amount of protein is estimated to be 3.3%. The percentage of sugar is about 0.8%. Extraction of Wax by solvent has resulted in a recovery of about 12 %.

The main material in this study is the Styrofoam waste and sugar mills industrial bagasse ash which composition is expected to produce eco-materials such as building materials that are environmentally friendly and have a light weight performance. By its light weight, then this material is expected to save the structure in building construction world. In this literature review, we are going to discuss about the main material used in the research referring to the literature review.

i. Light-Concrete, Styrofoam and Sugar Industry Fly-ash

Light weight concrete is concrete containing lightweight aggregate that meets the requirements of ASTM-C.330 provisions and has unit mass of dry air as determined by ASTM-C.567 which has density no more than 1900 kg/cm3. In manufacturing, lightweight concrete can be made with two methods. First method is to form a lightweight concrete using lightweight aggregates which are porous and have light density. The material produced is called as a light-weight aggregate concrete. The second method is to create a high pour in concrete either by adding air to the concrete or vacuuming the concrete. Light-weight concrete has been an option for developed countries to construct buildings, bridges and offshore building because its density is very low. Light-weight concrete is a building material that has been used by the people of Asia and Europe decades ago. Buildings with lightweight concrete are as a filler to reduce the risk of damage or collapsed by the earthquake due to the light mass of construction. Light-weight concrete is also able to reduce budget costs as the volume of structural elements such as columns, beams, floor plate and the foundation which can be reduced due to a light load Styrofoam is actually another form of plastic made from the styrene co-polymer or styrene polyp with another name. Styrofoam is usually used as a wrapping electronics, fast food, and fruit. However, the use of Styrofoam can cause harmful problems, both for health and environment. Moreover, the harmful content on Styrofoam like formaldehyde and benzene can cause other health related problems. Cavity on the Styrofoam can be the abode of bacteria and germs. Styrofoam is a material which is difficult to be destroyed and broken down by the environment, so that this material is more dangerous than plastic waste. This causes the Styrofoam waste accumulated and environmental issues that must be addressed immediately. The process of making Styrofoam also causes unpleasant odors and pollutes the air with 57 substances affecting the ozone layer. Consequently, Styrofoam contributes to the serious effects of global warming. The addition of Styrofoam in concrete is directly proportional to the decrease in the unit weight of the concrete. Measurement results on average unit weight can be seen in Table 2.

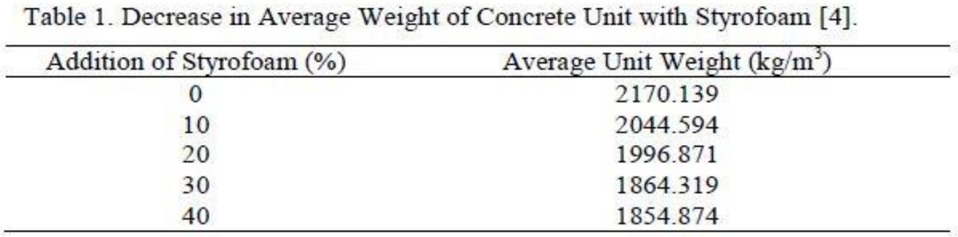


Table 1. Decrease in Average Weight of Concrete Unit with Styrofoam [4].

Addition of Styrofoam (%)	Average Unit Weight (kg/m^3)
0	2170.139
10	2044.594
20	1996.871
30	1864.319
40	1854.874

Bagasse is a side-product (residue) from the processing of sugar cane (saccharum oficinarum). Sugar cane is processed to take its sap used for the manufacture of sugar. Fresh sugar cane is obtained and milled up by a huge milling for several times until it contains sap that can be completely issued. Sugar cane milling process is done until sugar is completely dry of sap.

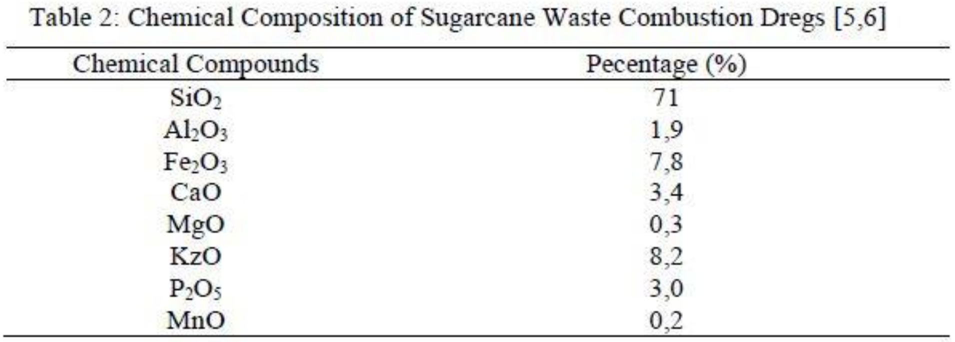
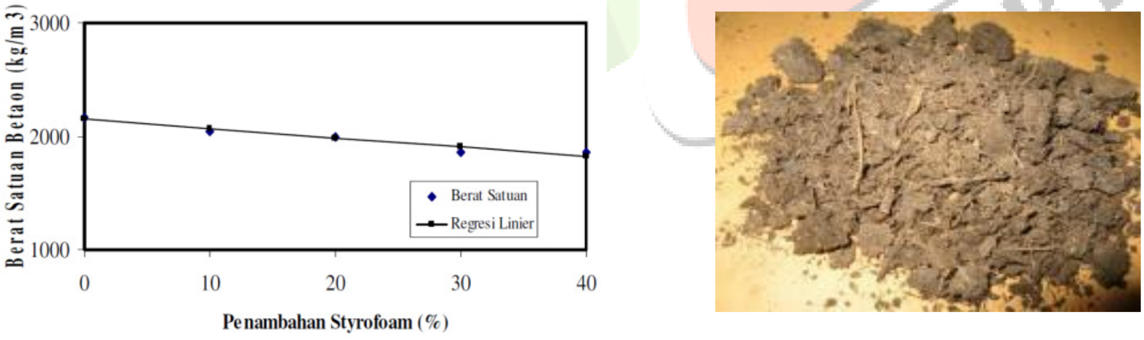


Table 2: Chemical Composition of Sugarcane Waste Combustion Dregs [5,6]

Chemical Compounds	Pecentage (%)
SiO_2	71
Al_2O_3	1,9
Fe_2O_3	7,8
CaO	3,4
MgO	0,3
KzO	8,2
P_2O_5	3,0
MnO	0,2



(a) **(b)**

Fig. 1 (a) Chart of Reduction in Unit weight of Concrete towards the addition of Styrofoam [4]; (b) Sugar Industry Fly-ash (Bagasse ash) [1].

When the sugar cane is still wet, then it is milled again by adding milk of lime juice 3BE that is capable of absorbing. Even though the volume is not as much as previous milling, the bagasse processing results sap is used in sugar mills for fuel heating boiler for producing steam boiler. The heating boiler process reaches 500℃-600℃ with long burning for 4-8 hours.

ii. The Increase of Concrete Compressive Strength with Waste Sugar cane pulp Combustion

Based on previous research, the addition of bagasse ash as a substitution of cement with the variation of 10%, 15%, 20%, 25%, 30% and 35% in concrete composition influences the compressive strength of concrete as seen in Table 3. It can be found out that the greater the compressive strength of concrete, the older the concrete age [7].

Table 3. The increase of Concrete Compressive Strength with Waste Combustion Variations Cane Dregs [7]

No	Code	Concrete Compressive Strength (Mpa)				
		7 days	14 days	28 days	50 days	90 days
1	BOAAT	24,25	27,72	33,48	43,78	49,67
2	B10AAT	31,28	33,32	36,85	48,82	56,10
3	B15AAT	30,25	32,90	37,05	49,86	57,12
4	B20AAT	27,65	31,75	36,52	47,37	54,56
5	B25AAT	26,77	31,05	35,76	45,95	52,23
6	B30AAT	24,91	30,10	34,44	40,39	45,24
7	B35AAT	23,67	28,41	34,25	38,42	42,24

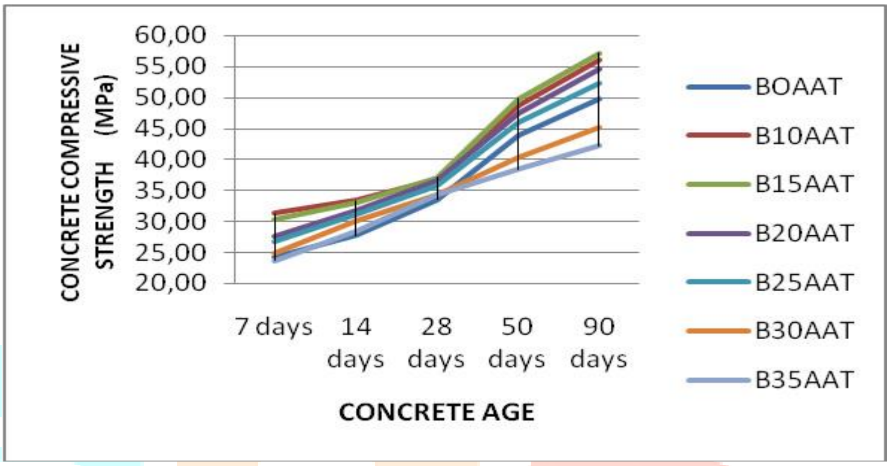
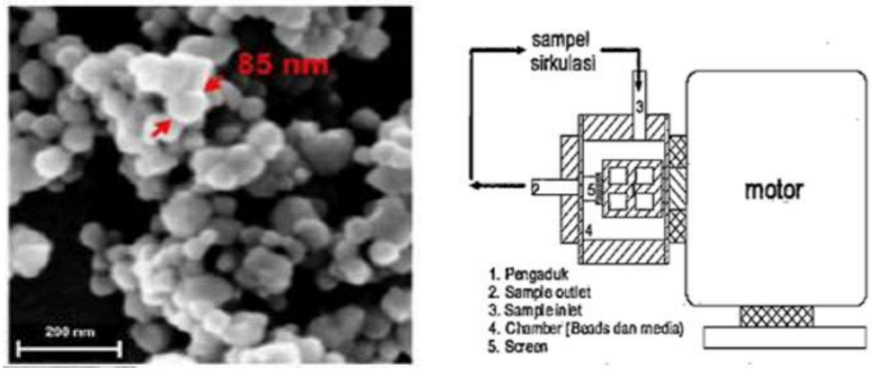


Fig. 2 Correlation graphs between concrete age and compressive strength [7].

iii. The principal mindset of Nano-materials with High Energy Milling and Characterization of Compounds with SEM

Basically, there are two approaches to get the nano-material. Firstly, is the Bottom Up and secondly is the Top Down. Bottom up is the method of getting the nano-material through chemical processes, such as liquid-phase techniques based on inverse micelles, sol-gel processing, Chemical Vapor Deposition (CVD), laser pyrolysis and molecular self-assembly. While Top down is the method of getting materials with nano-scale mechanical milling process using high energy milling tool [8].

This research used High Energy Milling to grind bagasse ash to be nano silica bagasse ash. The working principle of this device is to use the energy of collisions between balls and walls of the container crusher to grind the material that is initially micro-sized particles into nano-sized particles for 2 hours, with a rotation speed of 1200 rpm. It also used Scanning Electron Microscopy (SEM) to perform the characterization of compound. The SEM is a tool as an electron microscope that uses a beam of high-energy electrons to examine objects. It is conducted because the size of the nano particles is very small (10-9 meters), so it cannot be seen by light microscopy only by visible light which has a wavelength of about 400-700 nm [9,10].



(a) (b)

Fig. 3 (a)The characterization of compounds with SEM8 (b) High Energy Milling Machine [8].

VI. RESEARCH METHOD

This study aims to get research outcomes of eco-building materials such as bricks from the industrial waste as well as Nano-technology that have advantages over the other wall covering material. Advantages of building material are expected to have a compressive strength and sound absorption power that is high enough in value and able to be applied in sustainable development in Indonesia.

The Styrofoam is used as a substitute for coarse aggregate while the fine aggregate used is Muntilan sand as part of natural resource utilization outcomes Merapi mountain eruptions near Yogyakarta, Indonesia. From the results obtained for 7 days was that at an optimum power was contained in concrete with fly ash addition percentage of 15% with a value of 3.16 MPa and a compressive strength at 28 days to reach the compressive strength of 4.86 MPa. Concrete density was obtained up to 1165 kg/m3. Foam-brick also has relatively more stable temperature and lower than the temperature of solid brick market, Foam-brick maximum temperature is 39.5 °C while the maximum temperature is to 42.5 °C solid brick. The test object creation procedure is as follows:

i. Take cement, sand, Styrofoam and bagasse ash with a certain ratio (determined by the results of the design with Light Concrete Mix Design).
ii. Measure the weight of each material. Determine the value of water-cement ratio (FAS) based on Light Concrete Mix Design.
iii. Enter ingredients into pan in the order: all water, all the cement followed by bagasse ash, then followed with a partial sand and Styrofoam, turn over each other basis until exhausted.
iv. Prepare the concrete cylinder and cube mold which its parts are smeared Vaseline/oil.
v. Put the dough into the mold with concrete filling in three layers, each layer is approximately 1/3 volume.
vi. Prick each layer as much as 25 times (according to ASTM).
vii. Flatten the top of the mold with concrete, and then give concrete code and date of manufacture.
viii. Let is stand for 24 hours, after which the concrete soaks in water until the desired concrete age to be tested.

Tests performed at the age of 7 days, 14 days, and 28 days.

To determine the quality of the concrete with Styrofoam waste, then the following tests are performed:

i. The Compressive Strength

With the addition of Styrofoam and fly-ash substitution is expected to produce lightweight concrete with a higher compressive strength.

$$\sigma = P/A \qquad (1)$$

ii. Material Density

Obtaining the specific gravity level on Styrofoam and concrete with fly-ash.

$$MD = A/V \qquad (2)$$

This research is in the field of eco materials that its objective is to use Styrofoam waste and bagasse ash into an environmentally friendly building materials on the basis of nano-technology. Chronology of fish bone diagram of research will follow the scheme on the previous page.

VII. ANALYSIS

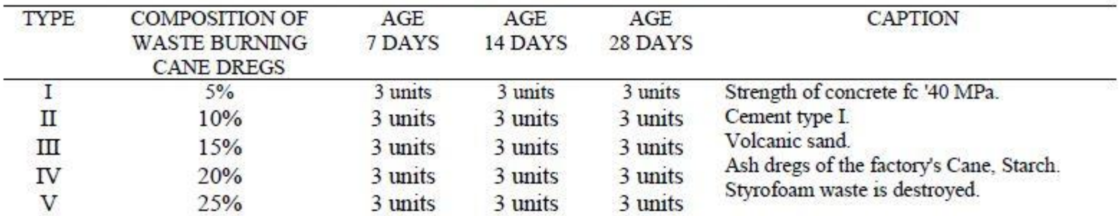
The fly ash retrieval was put from the factory located in the village of Trangkil, Pati, Central Java Province, Indonesia. The fly ash was taken from burning of bagasse itself, which is very much a waste by production process of the sugar factory. The Sand used in this research was the sand resulted from volcanic material of Mount Merapi in Magelang region, known as Muntilan sand. The choice of Muntilan sand is based on the excellent quality of the construction material. In addition, the material is also very abundant in the area after the eruption of Merapi, one of the active volcanic mountains in Central Java Province, Indonesia, in 2010; it is the other benefit of this material. The Styrofoam used in this study was firstly processed by using Styrofoam waste shredder (crusher foam). The bagasse ash was grinded by using High Energy Milling in order to produce silica nano-particles.

i. Light Concrete Mix Design

Concrete Mix-design is a method in the design of light-weight concrete. This method is based on the constituent materials of concrete, the coarse aggregate, fine aggregate, and cement as a compound. The Concrete Mix design method used in this study was the DOE method. It aimed to determine the composition ratio of the material, the ratio of coarse aggregate, fine aggregate and coarse aggregate in cement. In this research, the form of gravel in the manufacture of concrete was replaced with Styrofoam to make light-weight concrete. In addition, cement would be also as a binder substituted with the bagasse ash.

This study compared the concrete compressive strength and density of the bagasse ash composition of each varying with the purpose of seeking the optimal. Moreover, the composition testing was done in a vulnerable age concrete. For the compressive strength test specimens shall be made cylindrical ø = 15 cm and t = 30 cm. Each type of test object as much as 9 was each 3 specimens for 7 days, 3 specimens for 14 days and 3 specimens for 28 days.

Table 4. Number of objects test cylinders for each composition variation cane dregs.



TYPE	COMPOSITION OF WASTE BURNING CANE DREGS	AGE 7 DAYS	AGE 14 DAYS	AGE 28 DAYS	CAPTION
I	5%	3 units	3 units	3 units	Strength of concrete fc '40 MPa.
II	10%	3 units	3 units	3 units	Cement type I.
III	15%	3 units	3 units	3 units	Volcanic sand.
IV	20%	3 units	3 units	3 units	Ash dregs of the factory's Cane, Starch.
V	25%	3 units	3 units	3 units	Styrofoam waste is destroyed.

ii. Material Analysis

The foam-brick of research that we have done previously obtained optimal percentage in the addition of 15% (see Fig. 1 (b)) with bagasse ash mix design as follows:

Table 5. Optimal percentage of the addition of sugarcane waste combustion dregs 15% [1].

Cement	Sand	Split	Water
1	2.08	2.36	0.45

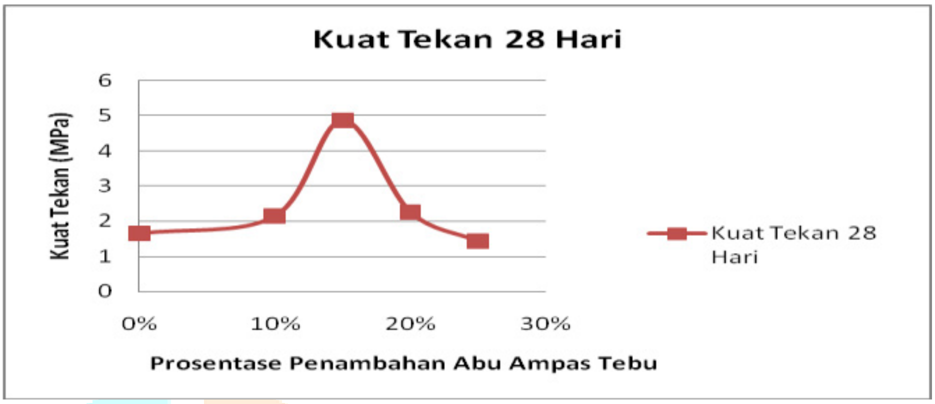


Fig. 4 The charts of Bagasse ash Addition to compressive strength of concrete [1].

Styrofoam is used as an aggregate substitution in concrete of 100% split on ratio of the volume.

VIII. RESEARCH FINDINGS

The advantages of using Styrofoam as aerated light-weight concrete and fly ash usage forming materials is addressed to find an eco-building material that has several benefits:

i. The use of waste materials will reduce the cost of manufacture and improve the value of industrial waste.
ii. Earthquake loads that work will be smaller because the weight of the structure is reduced, so that the structure will be safe and suitable for residential buildings in the earthquake area.

The pores allow the Styrofoam used as vibration and noise absorber.

IX. SUGARCANE BAGASSE ASH (SBA) MAIN CHARACTERISTICS

The sugarcane bagasse ash (SBA) has a dark appearance due to presence of a high amount of carbon contents and usually possesses a high moisture content if dispose in landfills. In addition, the residue SBA in sugar mill's boilers contains a high amount of silica (SiO_2) which usually absorbs from soil by the sugarcane roots at the growing time. The presence of silica diminishes transpiration of the sugarcane and helps it to keep more moisture. In addition to the natural absorption of silica, another source of silica is the sand existing in the sugarcane farms that is collected along with SBA at the harvesting time and accompany the SBA in the next stage in boilers (Sales and Lima 2010). A review on chemical components of the previous studies confirm that the main components of SBA is silica as summarized in Table 1. The table shows that the silica content of the untreated SBA usually varies between 61.6% to 96.2% as reported by the previous studies. The aluminium oxide known as gibbsite (Al_2O_3), iron oxide (Fe_2O_3), calcium oxide (CaO), magnesium oxide (MgO), potassium oxide (K_2O), sulphur trioxide (SiO_3), and sodium oxide (Na_2O) are other compounds that exist in different types of SBA. The gibbsite, iron oxide, and silica are the main compounds which react with calcium hydroxide and generate the pozzolanic reactions (Arenas-Piedrahita et al. 2016). The SBA particles can be prismatic, tubular, agglomerated or irregular. It has been indicated that the alkali contents such as sodium and potassium observed in agglomerated particles and silicon and oxide presented in prismatic particles. Also, more porous and agglomerated particles contain a higher amount of carbon as reported by Arenas-Piedrahita et al. (2016). They also come with various surface textures and variety of sizes and surface areas as indicated by Arenas-Piedrahita et al. (2016). The porosity of the SBA is related to the partially calcinated bagasse fibrous particles caused by its incomplete combustion (Arenas-Piedrahita et al. 2016).

A review of the loss on ignition (LOI) factor showed that this value varies between 0.3% to 21%. In fact, this value evaluates the percentage of weight loss arose from burning the unburned carbon and/or other organic contents in SBA. The raw/untreated SBA particles have an irregular shape and is known as a low-density and highly-porous material. A review of the specific gravity (SG) value of the used SBA which is the ratio of the SBA's density with that of water showed that this parameter varies between 1.51 and 2.65 as shown in Table 1.

The SBA counts as a natural pozzolans as per ASTM C618 (2015), however when directly is collected from the evaporators, its pozzolanic characteristic is less apparent due to presence of a high amount of carbon and crystalline silicate, and therefore some treating measurements such as grinding, sieving, and/or burning at specific temperatures are required prior to mixing with OPC as a pozzolan (Sales and Lima 2010; Cordeiro et al. 2009; Souza et al., 2007; Hernández et al. 1998). Reduction of the particle sizes by means of grinding or sieving increases the specific surface area which promotes the pozzolanic activities and the packing density due to micro-filler effects (Goldman and Bentur 1993). This increase is also helpful in settling of the fine pozzolan particles amongst cement minerals and helping in nucleation of hydrates on existing silica components in SBA and to reduce the energy obstruction. This process is known as heterogeneous nucleation (Lawrence and Ringot 2003). However, it should be considered that some of these measurements may take more cost or consume more energy which limits the cost effectiveness of the SBA as a pozzolan in OPC (Jagadesh et al. 2018). Table 1 also shows the mass median diameter (D50) and the specific surface area of the untreated/raw SBA used in different studies.

i. Effect of SBA characteristics

a. Effect of Particle Size Distributed (PSD)

The importance of the SBA's particle size distribution (PSD) was highlighted by Cordeiro et al. (2008). The raw SBA was ground for 8 to 240 minutes by means of a vibratory mill and the results showed that increasing the grinding time reduced the mass median diameter (D50) and increased the specific gravity and the pozzolanic index when mixed and tested with OPC and lime (Cordeiro et al. 2008).

They also performed a series of compressive strength tests on mortar specimens mixed with ground SBAs at different durations and indicated that the SBA's PSD has an inverse relation with the unconfined compressive strength (UCS) of the SBA added mortar and reducing the PSD increases the unconfined compressive strength (UCS) value. They indicated that the highest compressive strength values and pozzolanic activities achieved for the specimens containing the finest bagasse ash particle sizes (Cordeiro et al. 2008).

In addition, to better investigate the effect of pozzolanic reactions, they compared the UCS values of the specimens when mixed with ground crushed quartz (CQ) as an insoluble material and SBA (as a pozzolanic material) when both additives were ground using same method (i.e., tumbling grinding) at a similar packing density. The results showed that the compressive strength, pozzolanic activities and the mechanical response of the SBA added mortar was greater than the mortar mixture containing insoluble agent after a specific curing period. The recorded results were attributed to the effect of SBA's PSD in its pozzolanic reactivity (Cordeiro et al. 2008).

In another study, Bahurudeen et al. (2014) compared the pozzolanic index, workability and loss on ignition (LOI) of raw and processed SBA. Initially, the raw SBA was sieved through 300 μm and then ground for 120 minutes in a ball mill until it reached to the OPC fineness (i.e., 300-320 m2/kg). The recorded pozzolanic activity of the raw SBA was less than 75% which is required by ASTM C618 (2015) as a minimum value for a supplementary material to be counted as a pozzolanic material. The aforementioned process promoted pozzolanic activity of the SBA by 106% which is well above the minimum requirement. In addition, a higher water demand was required to achieve the same flow and workability for the mortar when raw SBA replaced in compare with processed SBA. A lower pozzolanic activity and a higher water demand was attributed to presence of the unburnt coarse fibrous particles of the raw SBA (Bahurudeen et al. 2014).

Cordeiro and Kurtis (2017) also investigated the role of SBA's PSD on strength and pozzolanic characteristics of the cement paste. In their study the raw SBA was ground for 8, 30, 120, and 960 minutes and four processed SBAs with four different PSDs was achieved and examined. The analysis showed that further grinding time caused a lower mass median diameter value which increased the BET specific surface area of the SBA. This high-energy ball-milling promotes dissolution rate of the silica and the strength activity index. They indicated that breakage of SBA's particles causes exposure of more amorphous silica as the crystallization of the silica during the burning of SBA happens from the surface to the interior of the particles. Also, pouring water to cool-off the SBA after burning in evaporators causes happening of a higher crystallization on the particle's surface (Cordeiro and Kurtis 2017). Jagadesh et al. (2018) evaluated and compared the mechanical behaviour of the concrete when mixed with two types of raw and processed SBA. The processed SBA was achieved by 45 minutes ball mill grinding of the raw SBA and then burning at 400°C in a furnace for 4 hours. The results showed that processing of the SBA caused an increase in specific gravity and the density and reduced the mean size mass particle size of the SBA. The results showed that the concrete specimens mixed with the processed SBA have a greater density than those mixed with raw SBA. It was indicated that the finer particles fill voids and well-distribute in the mixture and therefore provide a denser specimen, and a higher value of unconfined compressive strength (UCS) value. In addition, filling the pores is promoted even more when finer reactive silica presented in the processed SBA reacts with calcium hydroxide and generate calcium silicate hydrate (CSH). In fact, smaller particle sizes have a larger surface area and therefore a more promoted the pozzolanic activities within the specimens is recorded. Similar trend was recorded for modulus of elasticity (MOE) and the modulus of rapture (MOR) (Jagadesh et al. 2018).

Bahurudeen and Santhanam (2015) investigated the effect of different particle size on pozzolanic activity of the SBA. They initially burnt the bagasse at particulate temperatures and then removed the coarse and unburnt carbon fibrous particles by sieving through a 300 μm mesh. The remained SBA was ground at various timeframes until 210, 180, 150, 125, 105, 75, 53, 45 μm fineness was achieved. Then, the strength activity index and unconfined compressive strength tests were performed to evaluate the effect of particle sizes on pozzolanic activity of SBA. The results showed that only pozzolanic activity of the SBA with 53 and 45 μm fineness are equal/greater than the required pozzolanic activity index at 7 and 28-days curing periods and can be categorized as the supplementary pozzolanic materials to mix with OPC. To achieve the maximum pozzolanic activity, it was suggested to grind the raw SBA at the OPC fineness level (i.e., 300 m2/kg) after removing the coarse and carbonic fibrous particles through 300 μm sieve. This method also helps the processed SBA has a lower value of loss on ignition (LOI) and a minimum processing energy inputs in compare with other methods (Bahurudeen and Santhanam 2015).

Zareei et al. (2018) indicated that replacement of the SBA with a mass median particle size of 25 μm with OPC increase the water absorption of the specimens as the fine SBA's particle are not unable to fill the voids of the specimen and due to its carbon contents and irregular and porosity of SBA.

Cordeiro et al. (2009) investigated the effect of milling type and grinding circuit configurations. They indicated that different particle size distributions were produced by different mills and milling configurations, however it was indicated that the fineness is the most important parameter in forming pozzolanic activity of SBA. It was indicated that those specimens that have a D80 value less than 60 μm a specific surface area greater than 300 m2/kg can produce the required minimum standard of pozzolanic activity index. The results showed a good correlation between D80 values and the specific surface areas. It has been indicated that the pozzolanic activities of the bagasse ash have an inverse relation with presence of crystalline silica compounds. The crystallinity in silica forms due to over burning process or because of presence of sand (quartz) adhered to the sugarcane at the time of harvesting, and therefore, grinding bagasse ash is a way to reduce negative impacts of the crystalline silica and forming semi-crystalline or amorphous silica to improve pozzolanic activity of the SBA (Cordeiro et al. 2009).

b. Effect of SBA contents

Langade et al. (2018) investigated effect of SBA replacement by clay on mechanical and chemical properties of the brick. The results showed that addition of 60% bagasse ash is the most effective percentage of bagasse ash to improve the compressive strength value to the maximum level. Also, results indicated that the bricks manufactured by 60% bagasse ash are lighter and need a lower baking period (Langade et al. 2018).

In a similar study, Zareei et al. (2018) investigated effect of different SBA contents replacement with OPC on mechanical characteristics of a series of lightweight, self-compacting concrete specimens. The results showed that replacement of SBA was effective to improve unconfined compressive strength (UCS) of the specimens when 5% SBA was replaced with OPC. Also, the results showed that addition of bagasse ash increased general water requirement of the specimens due to presence of a high amount of carbon and irregular arrangements of SBA’s fibrous particles which formed a more porous medium and accordingly a higher water demand for SBA amended specimens.

Joshaghani and Moeini (2017) also investigated influence of SBA replacement on mechanical characteristics of the mortar. They investigated the effect of three percentages of sugarcane bagasse ash (i.e., 10, 20, and 30% by dry weight) and indicated that SBA was not effective to improve the UCS of the mortar specimens when the tests conducted at early curing periods. They also indicated that addition of SBA to the mixtures containing nanosilica reduced the compressive strength of the mortar at early curing periods, however, it was effective at higher curing periods.

Chusilp et al. (2009) investigated effect of treated SBA on compressibility, permeability, and heat production of the concrete specimens. The OPC was replaced with three SBA contents of 10, 20, and 30% (by dry weight of the binder). The results indicated that all SBA treated specimens had a greater compressive strength and a lower permeability in compare with benchmark specimen when cured at higher curing periods like 28 and 90 days. It was also highlighted that the specimens containing 20% SBA has the highest UCS value. Further analysis showed that increasing SBA contents of the specimens was effective to reduce their heat rise. It was concluded that the SBA is an effective pozzolanic by-product that can improve mechanical characteristics of the concrete (Chusilp et al. 2009).

In another example, Janbuala et al. (2018) investigated the effect of SBA on mechanical improvement of the pottery products by performing a series of compressive strength tests. They investigated effect of different percentages of SBA (i.e., 5, 10, 15, and 20% by dry weight) on clay and the results showed that increasing the SBA contents reduced the compressive strength and bulk density of the pottery products, however, it increased their porosity and water absorptions in compare with the control specimens without any SBA (Janbuala et al. 2018).

Kazmi et al (2016) also investigated effect of SBA replacement on durability and mechanical properties of brick specimens. Similarly, they noted that increasing the SBA contents in clay reduces the compressive strength of the bricks in compare with control specimen. They also indicated that the specimens containing SBA have a greater porosity which produce a lighter and a more cost-effective brick (Kazmi et al. 2016).

Rajasekar et al. (2018) investigated effect of SBA replacement on durability characteristics of ultra-high strength concrete specimens. They replaced four percentages of SBA (i.e., 5, 10, 15, and 20%) with cement. It was indicated that the SBA is effective to improve the compressive strength and to produce the ultra-high strength concrete specimens. Also, it was indicated that application of 15% is the most effective percentage for replacement of SBA (Rajasekar et al. 2018).

Srinivasan and Sathiya (2010) also investigated effect of SBA replacement with OPC in different percentages of 5, 10, 15, and 25% (by dry weight). The results showed that the specimens mixed with SBA had higher compressive, tensile, and flexural strengths. Also, it was indicated that 10% is the optimum SBA content that can be effectively replaced with OPC to achieve proper results (Srinivasan and Sathiya 2010).

Hasan et al. (2016) investigated effect of soil improvement by replacing SBA with lime. They used 4.5, 7.5, 13.5, and 18.75% as SBA percentages when replaced with 1.5, 2.5, 4.5, and 6.25% lime. The results showed that increasing the SBA contents reduced dry density of the and increased the California bearing ratio and the UCS value of the specimens (Hasan et al. 2016).

Jamsawang et al (2017) investigated effect of replacement of SBA with cement on improvement of clayey soil. They tested replacement of the different SBA contents (0, 10, 20, 30, 40, and 50%) and indicated that replacement of OPC is effective to improve strength characteristics of clay. Replacement of 20% SBA with OPC was considered as the most optimum contents.

c.Effect of Curing Periods

Cordeiro et al (2008) investigated effect of SBA addition on compressive strength of mortar specimens when the specimens were tested at three curing periods of 7, 14, and 28-days curing periods. The results showed that increasing the curing periods improved the compressive strength of the specimens at a specific grinding time in comparison with control specimen (Cordeiro et al. 2008).

Ganesan et al. (2007) also evaluated effect of SBA as supplementary material by performing a series of compressive strength tests on specimens replaced with different SBA contents while tested at 7, 14, 28, and 90-days curing periods. Similarly, the results showed that increasing the curing periods improved the compressive strength value in all specimens. They also investigated the relative increase in compressive strength of concrete specimens when mixed with 20% SBA. The results showed that increasing the curing periods reduced percentage of the increase in compressive strength and after 90 days curing the specimens had the lowest improvement (Ganesan et al. 2007).

X. MATERIALS

i. Sugarcane Bagasse Ash

The burning of bagasse which a waste of sugarcane produces bagasse ash. Presently in sugar factories bagasse is burnt as a fuel so as to run their boilers. India alone generates 90 million of bagasse as a waste material, from sugarcane industry. Bagasse is a residue obtained from the burning of bagasse in sugar producing factory. Bagasse is the cellular fibrous waste product after the extraction of the sugar juice from cane mills. Its currently used as a bio-fuel and in the manufacture of pulp and paper products and building materials. For each 10 tons of sugarcane crushed, a sugar factory produces nearly 3.1 tons of wet bagasse which is a by-product of the sugar cane industry. When this bagasse is burnt the resultant ash is bagasse ash. Western Maharashtra is having maximum number of sugar factories, these factories face a disposal problem of large quantity bagasse. The effective use of these waste products is a challenging task for a researcher through economic and environmental impact. This material contains amorphous silica which is indication of cementing properties.

ii. Press Mud

Press mud from the sugar mills is a very useful source of fertilizer as well as some chemicals. The major use that has recently been developed in India is in bio composting (usually trade named as Bio earth) where it is treated with the spent wash from the distillery. The concept of biological degradation of organic wastes by anaerobic digestion for the generation of methane has been used by waste management industries for many years. Press mud is an industrial waste available from the sugar mills.

The above waste materials are used as a replacement for cement and fine aggregate. Other than waste materials the materials which used in the manufacturing of bricks are as follows:

iii. Ordinary Portland Cement

Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. The magnesium oxide content (MgO) shall not exceed 5.0% by mass. Cement sets when mixed with water by way of a complex series of chemical reactions still only partly understood. The different constituents slowly crystallize and the interlocking of their crystals gives cement its strength. Carbon dioxide is slowly absorbed to convert the portlandite (Ca (OH)2) into insoluble calcium carbonate. After the initial setting, immersion in warm water will speed up setting. Gypsum is added as an inhibitor to prevent flash setting and quick setting.

iv. Fine Aggregates

Fine aggregate was purchased which satisfied the requirement of fine aggregate required for experimental work and conforming to zone-2, as per IS 383:1970. The sand was oven-dried and sieved to eliminate any foreign particles before mixing. Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight as given:

a. Fineness modulus: 2.81
b. Specific gravity: 2.61
c. Silt content: 2.63

v. Water

Water is an important ingredient of brick as it actually used for manufacturing of brick. Since it helps to bind all the raw materials for giving proper mix. Water used for making brick should be free from impurities. The common specifications regarding quality of mixing water are water should be fit for drinking. Such water should have inorganic solid less than 1000 ppm. This content leads to a solid quantity 0.05% of mass of cement when w/c ratio is provided 0.5 resulting small effect on strength.

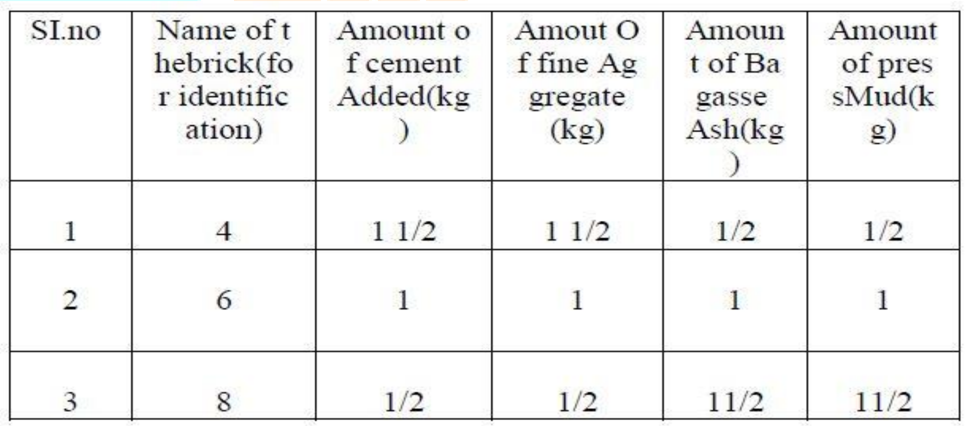
vi. Molasses

Molasses is a by-product recovered from the **sugar refining process**, due to molasses increases the fluidity of fresh concrete and also delays the **hardening time** of cement paste.

vii. Styrofoam

In the present work, it is, therefore, tried to reduce the density of the bricks, as well as improve **thermal insulation** properties. **Polystyrene foam** is one of the substances that is added to the raw materials of bricks, as a pore-forming material.

XI. MIX DESIGN



SI.no	Name of the brick(for identification)	Amount of cement Added(kg)	Amout Of fine Aggregate (kg)	Amount of Bagasse Ash(kg)	Amount of pressMud(kg)
1	4	1 1/2	1 1/2	1/2	1/2
2	6	1	1	1	1
3	8	1/2	1/2	11/2	11/2

XII. METHODOLOGY

i. Drying of waste materials

The waste materials are sun dried for a period of **12 hours** to eliminate the water content.

ii. Sieve Process

It is essential to sieve the fine aggregate and bagasse ash in Is sieve size of **4.5mm** for the proper binding of bricks.

iii. Mixing of materials

The above materials are mixed based on the mixed design for **proper binding.**

iv. Casting of Bricks

The mixture is casted in the mould of size **250mm x 120mm x 65mm**.

v. Casted Bricks

The casted bricks are named as **4, 6 & 8** based on the mix design, then the bricks are sun dried for a period of **5hrs** and it is subjected to curing for **28 days**. The cured bricks are undergone various test for identifying the strength.

XIII. TESTS ON BRICKS

i. Compressive Strength Test / Crushing Strength

The brick specimens are immersed in water for 24 hours. The specimen is placed in compression testing machine with 6 mm plywood on top and bottom of it to get uniform load on the specimen. Then load is applied axially at a uniform rate of 10 N/mm2. The crushing load is noted for the bricks named 4, 6, and 8.

ii. Water Absorption Test

A brick is taken and it is weighted dry. It is then immersed in water for a period of 16 hours. It is weighed again and the difference in weight indicates the amount absorbed by the brick. It should not in exceed 20 percent of weight of dry brick.

iii. Shape & Size Test

In this test, a brick is closely inspected. It should be of standard size and its shape should be truly rectangular with sharp edges. For this purpose, 3 bricks are selected at random and they are stacked length wise, along the width and along the height.

XIV. CONCLUSION

Based on the above experimental procedure and test, we conclude as:

i. Use of bagasse ash and press mud in brick can solve the disposal problem; reduce cost and produce a 'greener' Eco- friendly brick for construction.
ii. The crushing strength or compressive strength of bricks named as 4 is $9N/mm^2$ and the brick named as 6 is $6N/mm^2$ and the brick named as 8 is $5N/mm^2$.
iii. Hence, we strongly recommend brick 4 has a good compressive strength and suitable for construction.
iv. Environmental effects of wastes and disposal problems of waste can be reduced through this brick manufacturing process.
v. This study helps in converting the non-valuable bagasse ash and press mud into bricks and makes it valuable.
vi. In this research maximum compressive strength can be attained.
vii. The expected cost of the bricks can be reduced.

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