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Recent Studies of Sugarcane Bagasse Ash in Concrete and Mortar- A Review

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***Abstract*— In this article, the explanation and the major description of Sugarcane Bagasse ash (SCBA) have reviewed. This paper investigates the various process involved in the SCBA. This paper provides a historical point of view on the explanation and use of SCBA as a mineral admixture. This paper focuses on the mechanical and durability properties of SCBA in concrete and mortar.**

Keywords*— *Sieving, Grinding, Burning, Mechanical properties, Durability Properties

I. INTRODUCTION

One of the major grown crops in India is sugarcane. India is the second largest sugarcane producing country after Brazil. In sugar industries, the juice is extract from the sugarcane and the left over material is known as Bagasse. This fiber material used as a fuel in sugarcane industries and finally the ash obtained is known as Sugarcane Bagasse ash. It has prismatic, spherical and fibrous shape [1].

26% of bagasse ash and 0.62% of residual ash are approximately produced by one tonne of sugarcane [2]. SCBA has a major content of silica and it gives a good pozzolanic material [3]. This material has a crystalline structure and amorphous in nature [4,5]. Various by products of solid wastes also used as pozzolanic materials, it reduces the cement content [6]. This solid waste material gives a disposal problem which is reducing by using recycling process. Around the world in cement industry one tone of Portland cement emits approximately one tone of CO2.

SCBA is partially replaced in cement production reduced CO2 emission 519.3 Kilo tones per year [7]. For this purpose the solid waste materials is reduce the cost, waste emission and results in energy consumption [8]. The disposal of these material is also pollute the soils, underground water and leading to health problems [9]. The material having highly powdered of low density and high volume are characterized by any industrial process [9,10]. Bagasse ash is a mineral admixture used in concrete to attain the maximum strength, it should included by various process. It can also be used as ceramic materials like tiles, glass materials and soil blocks [11-15]. This waste material used to improve the soft clay, it could be used in sustainable construction technologies [16].

Nanotechnology can help to overcome major environmental challenges by reducing CO2 emissions and improve quality of cement [17]. Effect of SCBA with nano silica on mechanical and [18] and durability properties has studied [19]. It reduced the pores in the specimens due to bridging and filler effects in nano materials.

The aim of this paper is to study the mechanical and durability properties of SCBA. This knowledge could be beneficial for using the waste material (SCBA) in concrete and mortar.

II. MATERIALS

For preparing a concrete and mortar with SCBA ordinary Portland cement is usually used. Fine aggregate used as locally available river sand as well as SCBA is also used as sand replacement [5,20,21]

Super plasticizer or high range water reducers are chemical admixtures used where well dispersed particle suspension is required. That can be added to concrete mixtures to improve workability, reduce water-cement ratio and reduce cement content. Typical water reducers, reduce the water content by approximately 5-10%.

Melamine Formaldehyde consedate super plasticizer used to control the slump of fresh concrete [22]. Sikament NN super plasticizer used to achieve the superior workability and water reducing admixture [2]. Deionized water used as concrete mixture [23]. Type F super plasticizer used in cementitious material [24,25]. 20HE super plasticizer used for concrete production where higher water demand exists [10]. Conplast SP500 used in concrete[26].

Polycarboxylic ether based super plasticizer produce steric repulsion because molecular design introducing by long side chain on main chain [25]. This super plasticizer is compatibility with SCBA [4,19,23,27-30] because of the following reasons. It is a new generation of this kind of admixtures is represent by polycarboxylic ether based super plasticizer with a relatively low dosage [0.15-0.3% by cement weight] they allow a water to decrease upto 40% due to their chemical structure which enables the good particle dispersion.

III. PROCESSING METHODS

Raw bassage ash having unburnt particles, to give the good pozzolanic performance it included into various process. The methods are burning, sieving, grinding, chemical activation and the combination of above methods [4,6]. Adsorption and porosity increase due to low temperature of activation [31]. Carbon content affects the concrete properties [32]. Compressive strength decreased with high loss of ignition and increased with low loss of ignition [11,33]. Higher pozzolanic

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activity produced by finer SCBA [34,35]. Pozzolanic activity reduces alkalinity of cement pastes [36].

A. *Sieving*

Using sieving process increased the yield stress and viscosity of paste [25]. High carbon content would be removed by passing through 425 µm sieve [37,38]. Passing through 300 µm sieve was also used to remove the unburnt particles [4,6,27,39].To obtain a similar fineness of cement passing through 90 µm sieve used[36,40,41].

After grinding process, the material passed through 45 µm sieve
used as a cementitious material [5, 11, 19, 22, 23, 27, 33,38,42-45]
because smaller size particles increases the pozzolanic activity

B. *Burning*

To remove the carbon content, burning process will used. Burnt at 700^{0}C, SCBA gives the max pozzolanic activity[17] By using burning temperature @ 550^{0}C for 45^0 min reduces the loss of ignition [33]. 1000 to 1100^{0}C gives a poor pozzolanic activity [32]. Burnt @ 800^{0}C and 1000^{0}C @20min has a high and similar pozzolanic activity than kinetic diffusive model [11,40].

In some experiments SCBA burnt @ 600-800^{0}C [16,19,42,46]. Using different burning temperature [47], it concluded that @ 600^{0}C for 3h gives a low-carbon content and high specific surface area because loss of ignition was reduced.

C. *Grinding*

Two different methods were use to grinding, they are electrical

conductivity and mechanical response. In these two methods mechanical process gives the homogeneity and increase pozzolanic action [45]. Ultra finely produced SCBA produced by 42 kwh/t using ball mill gives fineness and homogeneity [28].
Grinding by using ball mill enhanced pozzolanic activity [4-6,9,22,24,33,39,42,46]. Ground for 120 min [27] gives 100% pozzolanic activity index [23]. SCBA gives a higher pozzolanic activity when it used as a substitute cementitious material [13,48].

IV. PROPERTIES OF CEMENT AND MORTAR WITH SCBA

It could be observed from literature survey of about 60 papers that SCBA used as partial replacement method in concrete and mortar based on the different processing methods.

TABLE -1 Comparing various research works published between 2000 and 2017

Research Team	Processing Methods	Mechanical Properties	Durability Properties	Year of Publication
Singh et al. [49]		10% of SCBA increases the compressive strength	10% of SCBA reduces the permeability	2000
Ganesan et al. [46]	Burnt at 650^{0}C for one hour Ground upto 5.4 µm size	20% of SCBA increases the compressive strength	20% of SCBA gives the minimum value of water absorption Up to 20% of SCBA given a lower permeability value 25% of SCBA decreased the chloride penetration and chloride diffusion	2007
Cordeiro et al. [44]	Grinding using ball mill for 240min Sieved using 45µm sieve	Compare to the control concrete SCBA mortar gives the higher compressive strength		2008
Nuntachai et al. [33]	Ground by ball mill Burnt at 550^{0}C for 45 min. Sieved using 45µm sieve	10-30% of SCBA gives a higher or equal result of control concrete	20% of SCBA gives a high sulphate resistance	2009
Akram et al. [2]		20% of SCBA increases the compressive strength		2009
Nuntachai et al. [39]	Ground by ball mill	20% of SCBA increases the compressive strength	30% of SCBA given lower permeability	2009

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 04, April-2018

	Sieved using 45µm sieve		SCBA increases, temperature in concrete decreases	
Almir et al. [21]		High values of compressive strength in 20-30% of SCBA in sand replacement		2010
Rukzon et al. [24]	Ground by ball mill Sieved using 45µm sieve	Compressive strength of concrete increases upto 30% of SCBA	Porosity of concrete increasing with increase more SCBA Water absorption of 20% and 30% of SCBA was higher at 28 days 30% of SCBA decreases the chloride penetration of concrete	2012
Rattapon et al. [43]	Sieved using 45µm sieve	20% of SCBA and flyash gives a higher compressive strength	20% of SCBA gives a lower permeability, high chloride penetration resistance and high sulphate resistance	2012
Rattapon et al. [50]	Sieved using 45µm sieve	20% of SCBA gives a higher compressive strength and modulus of elasticity	From 20–35% of SCBA improves the water permeability Upto 50% of SCBA gives a chloride resistance	2012
Sua – iam et al. [29]		20% of SCBA and limestone gives higher compressive strength		2013
Prasnshant et al. [20]		10% and 20% of SCBA increasing the compressive and tensile strength at later stages		2013
Kawade et al. [51]		15% of SCBA gives a higher compressive strength		2013
Nirita et al. [52]	Burnt at 600^{0}C for 6h and 700^{0}C for 3h Using furnace burnt at 1200^{0}C for 5h Ground by ball mill for 120 min.	10% of SCBA increases the compressive strength, flexural strength and split tensile strength		2013
Kawee et al. [11]	Burnt at 800-1000^{0}C Ground by ball mill Sieved using 45µm sieve	Upto 20% of SCBA gives the higher compressive strength		2013
Abdulkadhir et al. [38]	Burnt at 700^{0}C Sieved using 425µm sieve Grinding upto 45µm size	30% of SCBA increases the compressive strength		2014
Nidhi et al. [26]	Sieved using 150µm sieve	12.5% of SCBA increases the compressive strength		2014
Aukkadet et al. [22]	Ground by ball mill Sieved using 45µm sieve	Compressive strength of concrete increases upto 20% of SCBA at 90 days	10-50% of SCBA increases the chloride resistance of concrete and expansion due to Na2SO4 attack was less	2015

International Journal of Engineering Research & Technology (IJERT)
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Vol. 7 Issue 04, April-2018

		Upto 50% of SCBA did not affect the modulus of elasticity		
Bahurudeen et al. [4]	Sieved using 300µm sieve Grinding using ball mill upto cement fineness	Compressive strength of concrete increases upto 25% of SCBA	20% of SCBA gives less heat than control mix With increasing SCBA resistance of chloride and gas penetration increased Water penetration gives a significant reduction when the pressure applied SCBA concrete and control concrete has similar drying shrinkage	2015
Eramma et al. [18]		10% of SCBA and 2% of nano silica increases the compressive strength, flexural strength and split tensile strength		2015
Perira et al. [53]	Sieved using 2.38 mm sieve	25% of SCBA with blast furnace slag, gives higher compressive strength	Alkali activated mortar gives better performance than control concrete	2015
Tantaway et al. [41]	Burnt at 700^{0}C for 3h Sieved using 90µm sieve	15-20% of SCBA attained higher compressive strength at later stages	15-20% of SCBA decreases the porosity and alkalinity of mortar	2015
Chintan et al. [54]		5% of SCBA increases the compressive strength and flexural strength	5% of SCBA gives a sulphate resistance	2016
Juliana et al. [5]	Sieved using 4.8 mm sieve Ground using mechanical mill for 3 min.	30% of SCBA gives a higher compressive strength	Carbonation depth of 30% SCBA was same as control concrete Combination of SCBA and construction waste may result in delayed ettringite	2016
Lakshmi et al. [55]		10% of SCBA increases the compressive strength, flexural strength and split tensile strength Highest modulus of elasticity in 10% of SCBA replacement		2016
Elisabeth et al. [56]		5% of SCBA gives a higher compressive strength 15% of SCBA increase the pozzolanic activity	20% of SCBA improved sulphuric acid resistance	2016
Arenas et al. [57]	Sieved using 75µm sieve	15% of SCBA increase decrease compressive strength at early stages and increase in later stages	20% of untreated SCBA decreased the permeability and increased the electrical resistivity	2016
Syed et al. [39]	Sieved using 300µm sieve Ground by ball mill	Compressive strength increased upto 20% of SCBA	40% of SCBA shown the highest reduction in expansion leading to control alkali silica reaction distress	2017

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 04, April-2018

	Sieved using 45µm sieve		High amount of alumina and low CaO/SiO2 reduced alkali silica reaction expansion	
Elisabeth et al. [10]	Ground less than 10µm	10% replacement of SCBA increased the compressive strength and flexural strength of concrete	Drying shrinkage behavior improved up to 5% With increasing SCBA resistance of chloride penetration increased	2017
Kelam et al. [58]		12.5% of SCBA increases the compressive strength and split tensile strength		2017
Cordeiro et al.[30]	Burnt at 600^{0}C for 3h Ground by 120 min using ball mill		Coarsest SCBA present chemical shrinkage very close to portlandite content	2017
Latha et al. [59]	Burnt at 600^{0}C for 6h and 700^{0}C for 3h Sieved using 75µm sieve	10% replacement of SCBA increased the compressive strength and flexural strength and split tensile strength	7.5% of SCBA increased acid resistance 10% of SCBA increased sulphate resistance	2017
Parisa et al. [53]		10% replacement of SCBA increased the compressive strength and flexural strength		2017
Malikharjuna et al. [60]		12.5% of SCBA increases the compressive strength and split tensile strength	Impermeability characteristics improved in concrete	2017
Alireza et al. [19]	Burnt at 800^{0}C for 30 min Ground by ball mill less than 14 min Sieved using 75µm sieve	20% replacement of SCBA gives higher compressive strength	Due to filler effects of nano materials pores reduced SCBA and nano silica improves the resistance of chloride penetration At later stages it gives better electrical resistivity	2017

Based on the different processing methods of SCBA a strength and durability property varies shown in table 1. It observed that 20-30% of SCBA used as an optimum level when it involved into various processing methods.

V. CONCLUSION

Various methods of processing and production of SCBA mortar and concrete could be reviewed. From this review the following points were concluded

- 45µm sieve gives the better pozzolanic activity. Burning the material at 600-800ºC and grinding for 120 min gives the 100% pozzolanic activity
- It could be concluded 20-30% of SCBA increases the mechanical and durability properties
- The partial replacement of cement with SCBA reduces environmental problems, green house gases and global warming

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