International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 3 Issue 5, August 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Study on the Properties of Concrete Made with Sugar Cane Bagasse Ash under Acid and Alkaline Attack

Challa Hari Sravan[1], Mugipudi Manoj[2]

[1]Student, [2]Assistant Professor

[1,2]M.V.R College of Engineering &Technology, Vijayawada, Andhra Pradesh, India

How to cite this paper: Challa Hari Sravan | Mugipudi Manoj "Study on the Properties of Concrete Made with Sugar Cane Bagasse Ash under Acid and Alkaline Attack" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.677-681, **https://doi.org/10.31142/ijtsrd26422**

IJTSRD26422

ABSTRACT

Sugarcane bagasse is a sinewy waste result of the sugar refining industry. This item causes extreme ecological contamination, which calls for pressing methods for dealing with the waste. Bagasse powder chiefly contains aluminum particle silica, iron &calcium oxides. The fiery debris in this manner turns into a modern waste and postures transfer issues. So few investigations have been accounted for that sugarcane bagasse fiery debris as great pozzolanic material in incomplete substitution of the bond. In this project, the objective is to study the influence of partial replacement of Portland cement with sugarcane bagasse ash in concrete subjected to different curing environments. Experimental investigation on acid resistance of concrete in mgso4 solution. The variable factors considered in this study were concrete grade of M35 & curing periods of 7days, 28days, 60days, 90days, 180days of the concrete specimens in 1%, 2%, 3%, 4%, and 5% MgSO4 solution. Bagasse ash has been chemically & physically characterized & partially replaced in the ratio of 0%, 5%, 10%, 15%, and 20% by weight. Acidic assault on cement grants remarkable arrangement of harm systems and signs contrasted with other toughness issues of cement. Sulfuric corrosive assault restrains the administration life of solid components and, subsequently, results in expanded consumptions for the fix or at times substitution of the entire structure. To date, there is the absence of state-sanctioned tests for explicitly assessing the obstruction of cement to sulfuric corrosive assault, which has caused extraordinary fluctuation, for instance as far as arrangement focus, pH level/control, and so on., among past examinations here. Likewise, there is clashing information about the job of key constituents of cement (for example valuable cementitious materials [SCMs]), and vulnerability about construction regulations' stipulations for cement presented to sulfuric corrosive. Thus, the principal target of this theory was to survey the conduct of similar cement, arranged with single and mixed folios, to steady dimensions (mellow, serious and extreme) of sulfuric corrosive arrangements more than 36 weeks. The test factors incorporated the kind of bond (general use [GU] or portland limestone concrete [PLC]) and SCMs (fly fiery remains, silica seethe and nano-silica). The extreme (1%, pH of 1) and serious hostility (2.5%, pH of 0.5) stages caused mass loss all things considered, with the last stage giving clear qualification among the execution of solid blends. The outcomes demonstrated that the vulnerability of cement was not a controlling variable, under serious and extreme harm by sulfuric corrosive assault, while the concoction weakness of the folio was the prevailing component. Blends arranged from PLC performed superior to anything that of partners produced using GU. While the quaternary blends containing GU or PLC, fly fiery debris, silica smolder and nano silica demonstrated the most noteworthy mass misfortunes following 36 weeks, paired blends joining GU or PLC with fly cinder had the least mass misfortunes.

Keywords: *ALKALINE ATTACK, RCPT*

INTRODUCTION

Bagasse is a by-product of the sugar cane industry. The application of sugar cane bagasse ash (SCBA), one of the main by-products from the bagasse combustion, in concrete production provides an acceptable solution to some of the environmental concerns. Meanwhile, SCBA can be used as a mineral admixture in mortar and concrete because it presents proper chemical composition for application as a pozzolana, mainly in regard to its high content in silica. Several studies have been conducted to investigate the chemical effect or pozzolanic activity of SCBA and concluded that SCBA is a pozzolan, which improves the performance when mixed to cement.

SCBA is a pozzolan that can partially replace clinker in cement production, and its use improves the behavior of the cementitious material. The main products from the reaction between calcium hydroxide and SCBA are calcium silicate hydrates (C-S-H) gel. Singh et al. found that in the presence of SCBA, a large amount of C-S-H was formed in the paste, and the compressive strength increased. In addition, that SCBA used as a partial replacement for Portland cement could increase the mechanical properties and durability. High content in silica makes the SCBA be a pozzolan, but the presence of unburned material and carbon may reduce its reactivity.

SCBA would be classified as a pozzolanic material, and its reactivity depended mainly on the maximum particle size and fineness. The production of pozzolanic ash from SCBA requires the use of ultrafine grinding to transform this industrial residue in a mineral admixture, and coarser SCBA may be used as an inert filler in the cementitious mixtures [6, 8]. The effects of fineness and loss on ignition (L.O.I.) of SCBA on compressive strength and the kinetics of the pozzolanic reaction were reported by previous researchers [9–12]. However, SCBA advantages and optimum dosages resulting from chemical or physical effect are not yet clarified, and its application is limited. Further testing results are required.

Chemical attack of concrete by sulfuric acid is a chief durability concern worldwide, and the recent increase in the reported attacks in industrial zones, wastewater plants, sewage facilities, etc. by acidic media has drawn much attention to this topic. Sulfuric acid attack limits the service life of concrete elements, which basically are constructed to meet a target life span, and thus it results in increased expenditures on the repair or in some cases replacement of the whole structure. In the USA alone, the Congressional Budget Office estimated annual maintenance costs of $25 billion for wastewater systems during the period 2000-2019 (Sunshine, 2009). The most commonly known type of sulfuric acid damage occurs in concrete sewer pipes, treatment plants, pumping stations, manholes, junction chambers, etc. This type of corrosion is known by different names, such as microbial induced corrosion (MIC), biogenic sulfuric acid corrosion and hydrogen sulfide (H2S) corrosion. Also, sulfuric acid can originate from industrial wastewater and acid rain due to severe air pollution problems in megacities. For example, in China, it was reported that acid rain falls over about one-third of Chinese territories (Fan et al., 2010). High rise buildings made of concrete in these areas may be damaged due to exposure to frequent rainfalls with high acidity for a long time. In addition, sulfuric acid may be produced in groundwater and soils as a result of the oxidation of iron-sulfide minerals in the form of pyrites. Acid attack of concrete is generally classified as a chemical attack. The sulfuric acid reacts with calcium hydroxide (CH) and calcium silicate hydrate (C-S-H), the main hydration components in the cement paste, resulting in the precipitation of calcium sulfate. This reaction ultimately leads to decalcification and disintegration of the cementitious matrix (C-S-H gel, being converted ultimately to amorphous hydrous silica). Sulfuric acid has a combined attack by the proton (an acid) and sulfate attack in which the acid component enhances dissolution and thereby plays a significant role in the damage mechanism.

Table1.0: Chemical properties of SCBA

CHEMICAL COMPOUND	ABBREVATION	CONTENT(%)
Silica	Sio_2	68.42
Aluminum oxide	Al_2O_3	5.812
Ferric oxide	Fe_2O_3	0.218
Calcium oxide	Cao	2.56
Phosphorous oxide	P_2O_5	1.28
Magnesium oxide	Mgo	0.572
Sulphite oxide	SO_3	4.33
Loss on ignition	LOI	15.90

Procedures for Mixing

To attain homogenous dispersion of components, a specific sequence of mixing was adopted based on experimental trials to prepare six replicates of cubic (100×100×100 mm) specimens and three replicates of prismatic (100×100×350) and cylindrical (75×150 and 100×200 mm) specimens. The Na2SiO3 and NaOH solutions of desired quantity were mixed together with gauging water for 5-6 minutes about 24 hours before mixing with other ingredients. Right before mixing, air-entraining agent, superplasticizer and nanosilica were added to the water. All dry ingredients (FA and/or S, gravel and sand) were mixed in a mechanical mixer with a speed of 60 rpm for 2 min. The premixed liquid (alkaline activator) and water with air-entraining agent, superplasticizer and colloidal nanosilica simultaneously were added gradually in the mixer, and mixing continued for additional 3-5 min to achieve a uniform mixture. After mixing and casting the mixtures, a vibrating table was used to ensure good compaction of specimens. The top surface of the mixtures was sprayed by a curing compound (Fig. 3.9) made of high-grade hydrocarbon resins in a water-based emulsion conforming to ASTM C309 (2012) to mimic curing conditions in the field. The molds were then stored in laboratory condition (20°C and 50% RH) until testing.

Fig. 1.0: Spraying the top surfaces of the mixtures after casting by a curing compound.

Alkaline Attack:

To understand the effect of alkali exposure on concrete with different contents of SCBA, 56d normally cured concrete cube specimens were immersed in water with 5% sodium hydroxide. Compressive strength, UPV test and loss in weight was determined after 7d, 28d and 56d of chemical exposure. Three cubes were tested for each condition and the average is presented in the study.

Weight Loss

For water cured concrete, with an increase in SCBA from 0% to 30%, specimen weight was observed to be reduced at the end of 56d are shown in table 8. Fig. 5 shows the behavior of concrete with different SCBA content exposed to alkali for 7d, 28d and 56d. Exposure of concrete mixes to alkali attack showed an overall reduction in weight at exposure period of 7d, 28d and 56d compared to 56d weight of concrete specimens cured underwater. The specimen weight exposed to alkali was observed to reduce at a slower rate. The maximum loss in weight was observed with 0% and 30% SCBA content mixes for all alkali exposure period conditions. The minimum loss in weight was observed with 15% SCBA content at 7d, 28d and 56d exposure period.

For all exposure periods, the loss in weight was observed to be decreasing with increase in SCBA content from 0% to 15%, whereas above 15%

SCBA content the weight was observed to be decreasing up to 30% SCBA content. The residue weight at 56d alkali exposure was found to be 94%, 96% and 93% for 0%, 15% and 30% SCBA respectively. Inclusion of SCBA as cement replacement in concrete showed improvement in the results under alkali exposure condition.

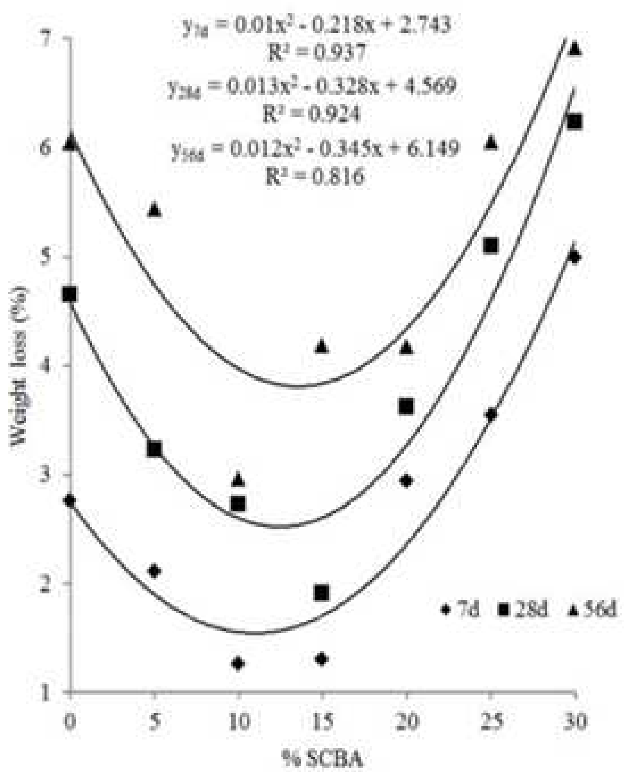


Fig.2.0: Effect of alkali attack on the weight of concrete containing SCBA.

Ultrasonic Pulse Velocity

The UPV results for different cement replacement conditions in concrete by SCBA cured under water for 56d. Pulse velocity values were observed to be increasing with the increase in SCBA up to 15%, whereas above this content velocity was found to be decreasing. As per IS 13311-1992 classification, concrete with 0% to 20% SCBA concrete can be considered to be excellent, whereas 25% and 30% SCBA concrete can be categorized as good. The compactness of concrete can be defined by higher velocity values.

Concrete specimens when exposed to alkali showed a reduction in UPV results compared to values of specimens cured underwater as shown in fig. 8. The maximum reduction in UPV during 7d and 28d exposure was found to be 9%, whereas at 56d the reduction was maximum with 0% SCBA concrete (i.e. 12%). Concrete with 5%, 10% and 15% can be categorized as excellent whereas other mixes as good, after being exposed to alkali attack.

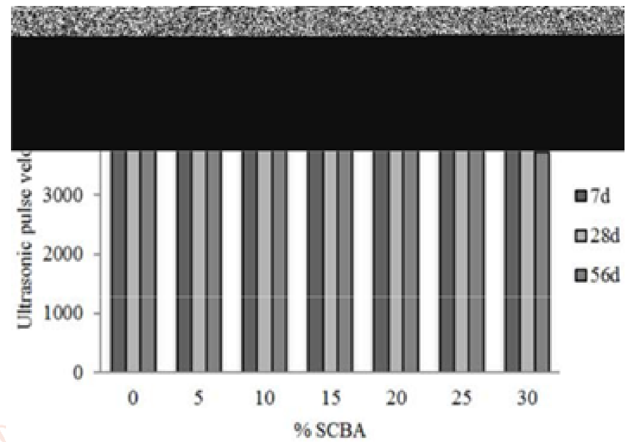


Fig 3.0: Effect of SCBA on Ultrasonic pulse velocity of concrete (WC-Normal water cured)

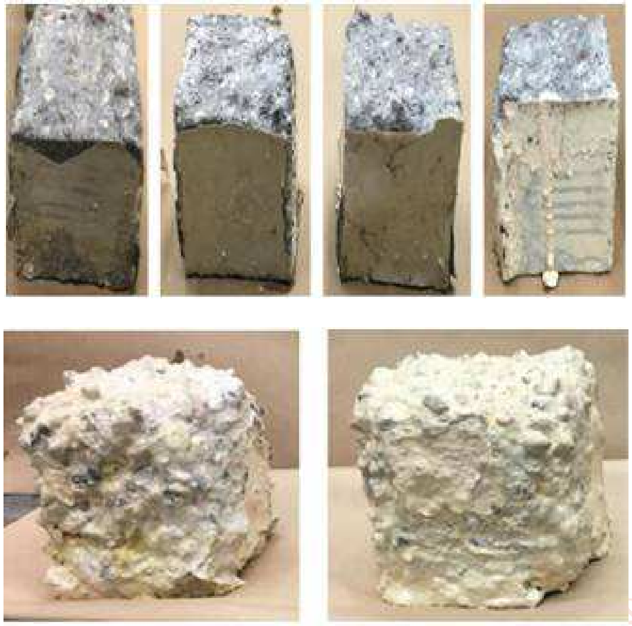
Absorption Test

The trends were mixed and overlapped during the first 40 min, as this initial absorption period is significantly affected by the composition of the skin layer (first few millimeters). This layer includes variations in paste content, aggregate distributions, sizes of capillary pores relative to the core of specimens which affected the behavior of absorption, giving inconclusive trends. Once this skin layer was saturated, the later absorption trends among the AAMs were distinctive between 40 to 360 min since they mainly governed by the proportion and sizes of accessible pores and their continuity (Tiznobaik and Bassuoni 2017a,b).

Specimens from the AAFA mixture experienced the highest total absorption depth after 360 min (about 1.35 mm), while AAS specimens exhibited the lowest total absorption depths (approximately 0.80 mm). This may suggest that slag based mixture had accelerated hydration and development of microstructure relative fly ash-based mixtures when cured at normal conditions (Lee and Lee, 2013). Incorporating 6% nano silica in a binary system (AAFA-NS) led to some reduction (approximately 9%) in the total absorption depth relative to that of AAFA. This might be attributed to the densification of the matrix, which is consistent with the slight increase in the compressive strength of AAAFA-NS. However, adding 6% nanosilica with slag in the binary slag system (AAS-NS) led to a minimal reduction in the total absorption depth relative to AAS, although AAS-NS showed significant improvement in compressive strength (37% increase). Adding 10% slag with fly ash in a binary system (AAFA-S) led to a significant reduction in the absorption depth (40%). This system showed the highest compressive strength among all mixtures, without the need for heat curing. Correspondingly, incorporating 6% nanosilica and 10% slag with fly ash in a ternary system (AAFA-S-NS) led to comparable results to that of the AAFA.

Fig. 4.0: Appearance of concrete specimens after 18 weeks of immersion in 10% sulfuric acid:

A. fly ash based AAMs, and b) slag based AAMs



Conclusions of Concrete with AAMs under Different Acidic &Alkaline Exposures

Considering the materials, mixture designs, and acidic exposures implemented in this study, the following conclusions can be drawn:

- The visual assessment showed that all specimens from the fly ash group exposed to continuous immersion in a very severe acidic solution underwent moderate deterioration without distinguishable features among mixtures. Comparatively, specimens from the slag group experienced progressive precipitation of gypsum (blocking effect) on the surface with notable swelling.
- All slabs from the fly ash and slag groups exposed to the cyclic environments combined with sulfuric acid solution showed significant deterioration (surface softening and scaling), reflecting the high level of aggressing of this exposure.
- The results showed that the inclusion of nanosilica and/or slag discounted the transport properties of fly ash based AAMs, as expressed by lower absorption capacity. Accordingly, the neutralization depths for blended mixtures incorporating nanosilica and/or slag decreased relative to AAFA specimens, which had rapid/full neutralization depth.
- On the other hand, specimens from the slag group exhibited the lowest absorption capacity and neutralization depths relative to that from the fly ash group, because of the blocking effect and lower initial absorption.
- Complying with the neutralization depth results, the mass loss results for the fly ash AAMs comprising slag and/or nanosilica (AAFA-S and AAFA-S-NS) showed lower mass loss compared to AAFA specimens in the combined exposure due to the lower penetrability and chemical stability of the geopolymerization products. Conversely, specimens from the slag group showed higher mass loss in the combined exposure, due to the continual wash out of the gypsum residue with cyclic environments and chemical vulnerability of their matrices to acidic deterioration.
- In comparison to AAFA, the pull-off test results showed that the bond strength of the AAFA-NS, AAFA-S, AAFA-S-NS increased after the combined exposure, due to the limited penetrability of the acid in the repair zone and continual geopolymerizationactivity at the interface with substrate concrete. Failure of specimens from slag group was mainly in the repair zone reflecting a higher level of deterioration with time.
- The reduction in weight due to sodium hydroxide exposure was observed to be decreasing with increase in bagasse ash content from 0 to 15% above which reduction rate increased at different exposure periods.
- Compressive strength and ultrasonic pulse velocity values were determined to be higher for the mix with 15% bagasse ash content at all alkali exposure periods.
- Inclusion of bagasse ash in cement aggregate mix showed improvement in resistance to alkali silica reaction Optimal utilization of SCBA in concrete for the maximum output was derived to be 15%.
- The overall results from this study suggest that fly ash based AAMs comprising slag and/or nanosilica, without heat curing after placement, are potentially a viable option for repair applications of concrete elements serving in acidic environments. Yet, field trials are still needed to document their performance, which is recommended for future research.

Recommendations for Future Work

The results and discussion presented in this thesis provide many useful insights for the extension of this research work. The following are recommendations for further investigations:

- Repeating the same incremental sulfuric acid exposure on mixtures composed of fly ash with different substitutions of slag and nanoparticles.
- Investigating the effect of different acidic concentrations and environmental conditions on the mechanisms of deterioration using similar mixtures.
- Calculating the diffusion coefficients of acidic solutions in alkali activated fly ash or slag based systems.
- Performing a field trial for the repair of concrete elements affected by an acidic attack using AAMs incorporating fly ash and slag without and with nanosilica and monitoring its performance

References

[1] ACI 201.2R. (2016). Guide to durable concrete. Report by ACI Committee 201, MI. *AmericanConcrete Institute*, Farmington Hills, USA.

[2] ACI 515.1R. (1985). Guide to the use of waterproofing, damp proofing, protective, and decorative barrier systems for concrete. Report by ACI Committee 515, MI. *American Concrete Institute*, Farmington Hills, USA.

[3] Adak, D., Sarkar, M., and Mandal, S. (2014). Effect of nano-silica on strength and durability of fly ash based geopolymer mortar. *Construction and Building Materials*, 70, 453-459.

[4] Adam, A. (2009). Strength and durability properties of alkali activated slag and fly ash-based geopolymer

concrete, Environment and Chemical Engineering. *RMIT University*, Melbourne, Australia.

[5] Al Bakri Abdullah, M. M., Kamarudin, H., KhairulNizar, I., Bnhussain, M., Zarina, Y., and Rafiza, A. R. (2012).Correlation between Na2SiO3/NaOH ratio and fly ash/alkaline activator ratio to the strength of geopolymer.*Advanced Materials Research*, 341, 189-193.

[6] Alexander M, Bertron A, De Belie N. (2013) Performance of cement-based materials in aggressive aqueous environments. *RILEM TC 211-PAE. Springer*, Berlin

[7] Alexander MG, and Fourie C. (2011). Performance of sewer pipe concrete mixtures with Portland and calcium aluminate cements subject to mineral and biogenic acid attack. *Materials andStructures*, 44(1), 313–30.

[8] Aliques-Granero, J., Tognonvi, T. M., and Tagnit-Hamou, A. (2017). Durability test methods and their application to AAMs: case of sulfuric-acid resistance. *Materials and Structures*, 50(1), 36.