

A review on strength characteristics of concrete incorporating sugarcane bagasse ash.

Una revisión sobre las características de resistencia del hormigón que incorpora ceniza de bagazo de caña de azúcar.

Fathima Shahin¹, Sangeetha S²

Department of Civil Engineering
Toc H Institute of Science and technology, Ernakulam(Kerala)India

Corresponding author mail id: fshahin786@gmail.com, sangeetha@tistcochin.edu.in

ABSTRACT

Sugarcane bagasse ash is an offshoot of sugar factories found after burning of sugarcane bagasse which itself is found after the extraction of sugar from sugarcane. The disposal of this material causes environmental problems surrounding sugar factories. Sugarcane bagasse ash is rich in silica that can play the role of an effective pozzolana which leads to improve pozzolanic reactions resulting in better performing building materials. Light weight concrete can be prepared from low density bagasse ash. Surface reactions are improved due to its high specific surface area. Some percentage of cement is replaced with bagasse ash to determine the fresh and hardened properties of the concrete mix. Compressive strength of the concrete can be improved tremendously on later stages of addition of bagasse ash. Incorporating sugarcane bagasse ash in concrete can further alter the other various performance of concrete.

Keywords—sugarcane bagasse ash, pozzolana, fresh and hardened properties.

RESUMEN

La ceniza de bagazo de caña de azúcar es una rama de las fábricas de azúcar que se encuentran después de quemar el bagazo de caña de azúcar que a su vez se encuentra después de la extracción de azúcar de la caña de azúcar. La eliminación de este material causa problemas ambientales en torno a las fábricas de azúcar. La ceniza de bagazo de caña de azúcar es rica en sílice que puede desempeñar el papel de una puzolana eficaz que conduce a mejorar las reacciones puzolánicas dando como resultado materiales de construcción de mejor rendimiento. El hormigón ligero se puede preparar a partir de cenizas de bagazo de baja densidad. Las reacciones superficiales se mejoran debido a su alta superficie específica. Algún porcentaje de cemento se reemplaza con ceniza de bagazo para determinar las propiedades frescas y endurecidas de la mezcla de concreto. La resistencia a la compresión del hormigón se puede mejorar enormemente en las etapas

posteriores de la adición de ceniza de bagazo. La incorporación de cenizas de bagazo de caña de azúcar en el hormigón puede alterar aún más el rendimiento del hormigón.

Palabras clave: ceniza de bagazo de caña de azúcar, puzolana, propiedades frescas y endurecidas.

INTRODUCTION

Admixtures can be used in concrete to improve its properties in various ways. Some of the common uses include improving workability, increasing or decreasing of curing time, and increasing the concrete strength. Admixtures can also be used for aesthetic performance, which include to change the colour of the concrete. Sugarcane bagasse ash is a mineral admixture and is an offshoot of sugar producing factories which is found after the extraction of all usable sugar from sugar cane. Sugarcane bagasse ash is mainly made of amorphous silica and can be used as a supplementary cementitious material in concrete. Limited studies have been carried out on bagasse ash as supplementary cementitious material. The utilization of bagasse ash is as a pozzolanic material in concrete. The pozzolanic reactivity of bagasse alter the compressive strength of concrete and also other mechanical and durability properties. The main compound in bagasse ash is silica oxide, therefore can be used as a potential material in concrete. The strength parameters of concrete improved by using 5% sugarcane bagasse ash as a partial substitute for cement. Up to 15% of sugarcane bagasse ash can be replaced with cement can be favourably used without compromising the primary properties of concrete. A considerable improvement in the compressive strength of concrete can be noted on utilizing 20% sugarcane bagasse ash. A slight alteration can also be seen in the fresh, mechanical and durability properties of concrete. Being a modern day construction material, engineered cementitious composite (ECC) can be produced using ground bagasse ash and is useful in repair works and prefabricated building components where high ductility is required.

SUGARCANE BAGASSE ASH

Sugarcane bagasse ash is a resultant waste product from cogeneration combustion boilers in sugar industries. It is rich in silica, plays the role of effective pozzolana and also considered as an effective mineral admixture. Processing methods significantly influence the pozzolanic activity of any supplementary cementitious material. Pozzolanic activity of sugarcane bagasse ash was evaluated based on different processing methods like burning, grinding, complete removal of coarse fibrous particles by sieving and combinations of these methods. All the process above shows different characteristics of sugarcane bagasse ash. Raw bagasse ash sample has lesser pozzolanic activity compared to that of burnt sample. Burnt bagasse ash at 700 °C showed maximum pozzolanic activity than 600°C and 800°C. Bagasse ash ground to less than 53 µm can be considered as a mineral admixture.

Sieving through 300 μm sieve and grinding to cement fineness of about 300 m^2/kg was considered as a best method to achieve pozzolanic activity due to the low value of loss on ignition and minimum processing energy of bagasse ash compared to other processing methods [Manu Santhanam, A Baharudeen (2015)].

COMPRESSIVE STRENGTH OF SUGARCANE BAGASSE ASH IN CONCRETE

Compressive strength shows a great variation on addition of sugarcane bagasse ash. This occurs due to the presence of ultrafine silica content particles and its ability to fill the pores in the mixture.

Sugarcane bagasse ash was partially replaced with the cement at 0%, 5%, and 10%, by weight in normal strength concrete (NSC). The compressive strength increases with incorporating sugarcane bagasse ash in concrete and it is indicated that the use of sugarcane bagasse ash in concrete (M20) at 5% altered the average part of compressive strength by 12% as compared to the normal strength concrete. The entire result of this work considered is that the maximum strength of concrete could be attained at 5% replacement of cement with sugarcane bagasse ash [Sajjad Ali Mangi et al. (2017)].

Replacing cement by 30% bagasse ash had no effect on mortar fresh state properties but was effective for compressive strength of 28 days. The compressive strength has altered due to the presence of silica and ultrafine particle size of sugarcane ash as it fills the voids. No significant increase in mortar compressive strength (7-17%) or mortar resistivity (15-28%) was observed from 28 days [Juliana Petermann Moretti, Sandra Nunes, Almir Sales (2018)].

Compressive strength of the mixture with 30% sugarcane bagasse ash and 30% slag blended cement substituting for ordinary Portland cement has increased about 8 to 11%. At a particular level of SBA, additional replacement of OPC by BFS resulted in lowering of compressive strength. [Duc-Hien Le et al. (2018)].

A physical effect of dilution of the Portland cement and the high carbon content in the sugarcane bagasse ash negatively affect the compressive strength of the concretes. On combining 10% sugarcane bagasse ash and 20% flyash did not affect the development of the strength of the concrete. The addition of 20% sugarcane bagasse ash decreased the strength of the concrete at early ages, but after 90 days it was similar to the strength of the control mixture [Venustiano Ríos-Parada et al. (2017)].

Ultra high strength concrete can be prepared with cylinder having compressive strength more than 160 MPa by addition of bagasse ash. 300 MPa compressive strength is achieved for heat cured specimen during 56 days with 15% ash content. Replacement ratio

of 15% provided better performance without formation of any adverse effects on hardened concrete [Rajasekar, Arunachalam, Kottaisamy, Saraswathy (2018)].

Partial replacement of cement with bagasse ash improve the performance of lightweight concrete more than other concrete types. Even 5% of ash content improved the strength properties of the mixtures due the fine silica particles present in them [Seyed Alireza Zareei et al. (2018)].

Untreated bagasse ash was partially replaced with 0%, 10%, 20%, 30% and 40% by volume of fine aggregate in concrete. The compressive strength of the mixes with 10% and 20% bagasse ash increases at 28 days (24MPa and 21MPa respectively) as compared to 7 days (11MPa and 10MPa respectively) be due to pozzolanic properties of bagasse ash [Prashant O Modania, M R Vyawahare (2013)].

Concrete prepared with the application of sugarcane bagasse ash sand and construction waste achieved 93% of the compressive resistance of the control concrete [Juliana P. Moretti et al. (2016)].

CHARACTERISTICS AND PROPERTIES OF SUGARCANE BAGASSE ASH IN CONCRETE

Various properties like workability, density, shear strength, corrosion resistance, sulphate resistance, electrical resistance can be altered. The sugarcane bagasse ash also gives suitable slump values which can enhance the workability of concrete [Sajjad Ali Mangi et al. (2017)]. The bagasse ash can be used as filler material for enhancing self compatibility, strength, durability due to the pozzolanic action of sugarcane bagasse ash [Juliana Petermann Moretti, Sandra Nunes, Almir Sales (2018)]. Replacing either sugarcane bagasse ash (SBA) or slag blended cement (BFS) to ordinary portland cement in mixtures led to minimum flowability. The density level of self-compacting concrete with slag blended cement was 1.4% to 10% lesser than that of control mix irrespective of BFS replacement level. When the SBA content is higher more will be the water absorption. Electrical resistivity is highest for mixture containing lowest SBA (10%) and highest BFS (30%). Presence of SBA and BFS improved the resistance to sulphate attack. When BFS is further replaced with OPC made the sulphate resistance to be remarkably improved, mainly for mixture containing highest ratio of SBA (30%) and also majority of SCC samples had a negligible corrosion rate after 28-day ages [Duc-Hien Le et al. (2018)]. The larger volume of total pores, the use of sugarcane bagasse ash results in the reduction of workability and volumetric weight but the air content and the temperature in the fresh state are not affected [Venustiano Ríos-Parada et al. (2017)]. When beams made with 15% replacement of cement by sugarcane bagasse ash and 20% replacement of sand by laterite soil provide higher shear strength without any shear reinforcement also enhances the

deflection at ultimate applied load. On increase in the partial replacement levels the ultimate cracking load and ultimate shearing stress decreases [R.A. Shuaibu, T. Nyomboi & R.N. Mutuku (2015)]. Bagasse ash improves workability, compressive strength mainly due to the fine particle size of ash and presence of silica content whereas resistance to chloride ion penetration improves as the charge passed is less for finer SBCA particles and also bagasse ash decreases rate of water absorption [Rajasekar, Arunachalam, Kottaisamy, Saraswathy (2018)]. Increase in water absorption also noted due to the low ability of raw bagasse ash to fill the pores. Finally found the incorporation of bagasse ash improved durability and quality of even self- compacted concrete [Seyed Alireza Zareei et al. (2018)]. From the sorptivity coefficient increases with the increase in percentage of bagasse ash which indicates that it is more permeable concrete due to the porous nature of SCBA and the impurities present in it. Hence bagasse ash is a potential ingredient of concrete as it can be an effective replacement to cement and fine aggregate [Prashant O Modania, M R Vyawahare (2013)]. The modulus of elasticity of concrete with 50% of CW is lower. The formation of delayed ettringite in concrete produced using the combination of SBAS and CW can harm the durability of concrete samples. When SBAS and CW increases, the amount of water in the mixture also increases for maintaining the consistency constant [uliana P. Moretti et al.(2016)]. The super plasticizer was increased with increase in bagasse ash replacement. There is a decrease in relative fluidity of bagasse ash based cement paste whereas paste volume has to be increased with bagasse ash replacement due to its low relative density and led to reduction in relative fluidity%. Raw bagasse ash has low value of pozzolanic activity compared with the minimum requirement in the standards, but this can be overcome by sieving through 300 mm sieve and again grinding it to the cement fineness ($300-320 \text{ m}^2/\text{kg}$) to produce bagasse ash with higher pozzolanic activity, better workability and low loss on ignition for the production of bagasse ash based portland pozzolana cement [Bahurudeen et al. (2014)].

CONCLUSION

The main compound in sugarcane bagasse ash is silica oxide and therefore can be used as a potential member in concrete. The compressive strength of concrete altered at 5% to 10% replacement of cement with bagasse ash. Workability characteristics of concrete increased by increasing the percentage of replacement of SCBA in concrete. When there additional increase in percentage of SCBA may decrease in compressive strength. The tensile strength of concrete decreases with addition of SCBA.

From various other studies, 300MPa compressive strength is achieved for heat cured specimen with 56 days with 15% sugarcane ash content mainly due to the ultrafine particle size and silica content of sugarcane ash. Increase in water absorption occur in concrete due

to the low ability of bagasse ash to fill the pores (bagasse ash content higher than 15% in concrete). Compressive strength of specimen made from mixture with 30% SBA and 30% BFS substituting for OPC were comparable to that of control mix (increased about 8 to 11%). The compressive strength of the mixes with 10% and 20% bagasse ash increases at 28 days (24MPa and 21MPa respectively) as compared to 7 days (11MPa and 10MPa respectively) that may be due to pozzolanic properties of bagasse ash. Concrete samples made with the joint application of sugarcane bagasse ash and construction waste achieved 93% of the compressive resistance of the control concrete mix. Compressive strength shows a good increase when incorporating sugarcane bagasse ash in concrete.

ACKNOWLEDGMENT

Finally, we give all honour and praise to God Almighty for giving us wisdom, strength and patience for the completion and submission of this paper. We would like to acknowledge the support and cooperation extended by the department of civil engineering of Toc H Institute of Science And Technology.

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Received: 15th February 2021; Accepted: 20th March 2021; First distributed: 29th March 2021