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Experimental Investigation of Bagasse Ash and Metakaolin in Concrete with Superplasticizer Conplast SP430

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ABSTRACT—

Indigenous resources for natural and artificial mineral admixtures with high pozzolanic reactivity have been employed in many countries around the world. Extensive studies have been conducted for this purpose. With the use of agricultural waste residue, apart from improving properties of concrete, main benefits come from saving natural resources and energy, as well as protecting the environment by using these mineral admixtures. Sugarcane bagasse (SCB) is a voluminous by-product in the sugar mills when juice is extracted from the cane. The burning of bagasse leaves bagasse ash (BA) as a waste.

Bagasse ash can be used as a cement replacement material because of its pozzolanic property. Replacing cement with (10-20% by weight) bagasse ash produces a concrete mix. Metakaolin is a pozzolanic material widely used in partial replacement of cement (5–20% by weight) which is economical and its pozzolonic action increases the strength and durability properties. From the experiments it is obtained that partial replacement of bagasse ash with cement increases strength up to 15 %. In this paper a green technology is evolving to replace maximum amount of cement by bagasse ash and metakaolin. So by fixing 20% of bagasse ash as constant, metakaoiln can be blended to the concrete mix to increase the strength and durability by varying percentage of 0, 5, 10, 15, and 20. The tests conducted are compressive strength test,split tensile strength test,flexural strength test and durability tests such as chloride attack and sulphate attack.

Keywords— Metakaolin, Superplasticizers, Bagasse Ash

INTRODUCTION

Concrete is certainly the most important construction material in the world. Its use is over 10 billion tons per year and, when done well, concrete can present good mechanical strength, and also, acceptable durability performance. The main component of concrete is the binder that normally is composed of Portland cement, and in some cases, the presence of mineral additions, such as fly ash or silica fume, can also be observed in its composition. Cement which is one of the ingredients of concrete plays a great role, but it is most expensive. Portland cement is the conventional binding material that, actually, is responsible for about 5%–8% of global CO2 emissions. This environmental problem will most likely be increased due to exponential demand of Portland cement: By 2050, demand is expected to rise by 200% from 2010 levels, reaching 6000 million tons/year.

Metakaolin is a supplementary cementing material which is produced from carefully calcining kaolin clay between 600^0C and 800^0C to make it reactive. Metakaolin is composed mainly of alumina and silica phases, which can vary by approximately 10% and 8% respectively depending on the kaolin source. Metakaolin has the general form Al2O3SiO2. When blended with Portland cement in appropriate amounts, typically below 10%, it will enhance the strength and durability of the concrete. Replacement of Portland cement by sugarcane bagasse ash and metakaolin on weight basis seems to be very suitable for Indian construction industry due to abundant availability of bagasse ash and metakaolin at cheap cost. Utilization of bagasse ash also solves the problem of disposal of bagasse ash.

The main composition of bagasse ash is siliceous oxide sio2 that react with free lime from cement hydration. The pozzolanic property of SCBA came from the silicate content of the ash. This silicate under goes a pozzolanic reaction with the hydration products of the cement and results a reduction of the free lime in the concrete. The silicate content in the ash may vary from ash to ash depending on the burning and other properties of the raw materials like the soil on which the sugar cane is grown. Therefore, this study attempts to make use of the SCBA in India as a pozzolanic material to replace cement. An experimental investigation was carried out explore its Consistency, setting time, workability, compressive strength, split tensile strength, flexural strength and durability characteristic.

BAGASSE ASH

Bagasse is the waste produced after juice extraction in Sugar industry, which is usually used as a fuel for boilers in the sugar mills and alcohol factories which produce high amounts of ash annually. The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Each ton of sugarcane generates approximately 26% of bagasse (at a moisture content of 50%) and 0.62% of residual ash. The residue after combustion presents a chemical composition dominates by silicon dioxide (SiO2). In spite of being a material of hard degradation and that presents few nutrients, the ash is used on the farms as a fertilizer in the sugarcane harvests. Sugar cane bagasse ash is recently accepted as a pozzolanic material, study of using bagasse ash as a pozzolanic material is not well-known.

COMPOSITION OF BAGASSE ASH AND OPC

COMPONENT	BA MASS%	CEMENT MASS %
SiO_2	78.34	20.85
Al_2O_3	8.55	4.23
Fe_2O_3	3.61	5.25
CaO	2.15	63.49
Na_2O	0.12	0.16
K_2O	3.46	0.4
P_2O_5	1.07	-
LOSS OF IGNITION	0.42	1.05

METAKAOLIN

Metakaolin is refined kaolin clay that is fired (calcined) under carefully controlled conditions to create an amorphous aluminosilicate that is reactive in concrete. Like other pozzolans (fly ash and silica fume are two common pozzolans), metakaolin reacts with the calcium hydroxide (lime) byproducts produced during cement hydration. Metakaolin is a chemical phase that forms upon thermal treatment of kaolinite. Kaolinite's chemical composition is Al2O3.2SiO2.2H2O and as a result of thermal treatment in the range of 400-500ºC, the water is driven away to form an amorphous alumino silicate called metakaolin. The temperature range depends on the kaolin (kaolinite with minor impurities) characteristics such as degree of crystallinity and particle size.

LITERATURE REVIEWS

A study was conducted on concrete by replacing cement with sugarcane bagasse ash (SCBA).SCBA has been chemically and physically characterized and partially replaced in the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight of cement in concrete. The properties for fresh concrete are tested like slump cone test and for hardened concrete compressive strength at the age of 7, 28, 56 and 90 days. The test result indicate that the strength of concrete increase up to 15% SCBA replacement with cement. Workability of the concrete increases with increase in bagasse ash content (Mrs.U.R.Kawade, Mr.V.R.Rathi and Miss Vaishali D. Girge)

They conducted studies on properties and reactivity of SCBA. Ashes obtained after control burning of SCB at 600ºC/5hour were reasonably reactive given by the fact that little crystallization of minerals occurred. Morphological, XRD and TGA/DTA study of the blended pastes confirmed the hydration reaction of SCBA within the cement gel. Compressive and flexural strength tests confirmed the actual behaviour of SCBA blended mortars and it suggested that up to 15% substitution of OPC with SCBA can be made with better strength results than that with pure cement (Ajay Goyal, Hattori Kunio, Ogata Hidehiko and Mandula)

Initiatives are emerging worldwide to strike a balance between the developments in infrastructure and prevention of the environment from contamination by reusing the industrial wastes. The feasibility of using Sugarcane Bagasse Ash (SBA), a finely ground waste product from the sugarcane industry, as partial replacement for cement in conventional concrete is examined. The tests were conducted as per Bureau of Indian Standards (BIS) codes to evaluate the suitability of SBA for partial replacements up to 30% of cement with varying water cement (w/c) ratio .The physical properties of SBA were studied. Compressive strengths (7, 14 and 28 days) were determined. The results showed that the addition of sugarcane bagasse ash improves the strengths in all cases. The maximum strength increase happens at 15% with 0.35 w/c ratio. Based on the conducted experiment and according to the results obtained, it can be concluded that: Bagasse ash can increase the overall strength of the concrete when used up to a 15% cement replacement level with w/c ratio of 0.35.Bagasse ash is a valuable pozzolanic material and it can potentially be used as a partial replacement for cement. This could reduce the environmental problems and minimize the requirement of land fill area to dispose SBA (Lavanya M.R)

The present study investigates with the strength and durability properties of the concrete when the cement is replaced with S.C.B.A in different proportions. In the first stage the S.C.B.A (B.A.1) is partially replaced in the percentages of 0 to 40% in increasing steps of 5%. Further in the second stage the S.C.B.A (B.A.2) is heated up to 850^0c for about 8 hours in a muffle furnace and is replaced in the percentages of 0 to 40% in increasing steps of 5%. Cubes, Cylinders and Beams are casted and tests are conducted and compressive strength, split tensile strength and flexural strength obtained for both the conditions. Based on this study it can be concluded that, The maximum compressive, split tensile, flexural strengths are obtained at 5% when the cement is replaced with B.A 1. The maximum compressive strength is obtained at 15%, tensile strength is obtained at 20% and flexural strength is obtained at 30% when the cement is replaced with B.A 2. Comparing the results of the two trails, the results obtained by replacing cement with B.A.2 are better. Hence it can be concluded that B.A.2 is most preferable than B.A.1 as cement replacement material, and hence S.C.B.A is a good pozzolanic material (Sireesha Et Al)

PHYSICAL PROPERTIES OF CEMENT

S No.	Properties	Test results	IS Specifications
1	Specific gravity	3.14	-
2	Standard consistency (%)	32	-
3	Initial setting tim (min)	30	>30
4	Final setting time(min)	600	<600

DESIGN STIPULATIONS

fck required = 30 N/mm^2

Max size of aggregate = 20 mm

Degree of workability = 80 mm

Slump Degree of quality control = Good

Type of exposure = Moderate

PROPERTIES OF SUPERPLASTICIZERS

Aspect	Dark brown free flowing liquid
Relative density	1.24 ± 0.02 at 25^{0}C
pH	> 6
Chloride ion content	< 0.2%

CONSTITUENTS

W/C	0.4
Coarse aggregate	1223 kg
Fine aggregate	629 kg
Cement	360 kg
Water	144 kg

MIX PROCEDURE

All materials were batched separately by weight. Aggregates were weighed under saturated surface dry conditions. Mixing of concrete was carried out using a laboratory mixer. First the coarse aggregate and fine aggregate were mixed. After that the cement was poured into the mixer, and then water along with the superplasticizer was poured and mixed well for 2 minutes.

RESULT

The property of concrete which determines the amount of useful internal work necessary to produce full compaction is known as workability. The workability of fresh concrete depends mainly on the material, mix proportion and environmental conditions. Generally workability of concrete decreases on addition of metakaolin and increases on addition of bagasse ash.

The workability of concrete is measured using slump test. The results show that compared to the normal concrete, all investigated bagasse ash mixtures had high slump values and acceptable workability. Sugarcane bagasse ash requires less water for wetting the particles compared to cement. But the mixture with 20% metakaolin and 20% bagasse ash showed low slump compared to the control mix. Metakaolin has extremely high surface area, which results in increase in water demand to maintain consistency.

SLUMP VALUES

Mix designation	Metakaolin %	Bagasse ash %	Slump (mm)
NC	0	0	100
BM 0	0	20	110
BM 5	5	20	106
BM 10	10	20	102
BM 15	15	20	100
BM 20	20	20	97

CONCLUSIONS

Based on limited experimental investigation on the physical and chemical properties of materials

1. It has been observed that the mix design for the experiment is 1:1.75:3.4.
2. The physical properties of fine and coarse aggregate were determined.
3. The fineness Modulus of River sand is coming under recommended value.
4. Obtained physical properties of cement.
5. Control specimens were casted.
6. The properties of fresh concrete and hardened concrete were determined.
7. The compressive strength of concrete with different curing periods of 7 and 28 days were studied.
8. Compressive strength of control concrete increases as the curing period increases for M30 grade concrete.
9. The replacement of cement with bagasse ash and metakaolin increases the compressive strength, upto 15% replacement of metakaolin. Durability decreases with increase in metakaolin content.
10. Optimum strength is obtained for 10% metakaolin and 20% bagasse ash replacement for sulphate and chloride tests.
11. Better tensile strength is also achieved by ternary blended concrete.
12. Load-Deflection behaviour of normal concrete reinforced beam and Ternary blended concrete reinforced beam is merely similar but ternary blended concrete reinforced beam behaves better.

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