Available online at www.elixirpublishers.com (Elixir International Journal)

Civil Engineering

Elixir Civil Engg. 60 (2013) 16171-16174

ISSN: 2229-712X

Incorporation of agrosilica in concrete-a review

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ARTICLE INFO

Article history:

Received: 17 May 2013;
Received in revised form: 17 June 2013;
Accepted: 3 July 2013;

Keywords

Sugarcane bagasse ash,
Rice husk ash,
Wood ash,
Concrete,
Compressive strength,
Split tensile strength,
Flexural strength.

ABSTRACT

The experimental study has been made to utilize natural agrosilica (agrowaste) as a pozzolana by partial replacement of cement. The agrowastes that are rich in silica namely sugarcane bagasse ash, rice husk ash, wood ash are being taken for the study. The study is done for compressive strength, split tensile strength, flexural stength. Optimum percentage of replacement of different agro waste is determined. Thus utilization of agro waste in concrete and accounts for green concrete.

Introduction

With the ever increasing demand and consumption of cement and in the backdrop of waste management, scientists and researchers all over the world are always in quest for developing alternate binders that are environment friendly and contribute towards sustainable management.

Pozzolanas are materials containing reactive silica and/ or alumina which on their own have little or no binding property but, when mixed with lime in the presence of water, will set and harden like a cement. They are an important ingredient in the production of alternative cementing material to Portland cement (OPC).

A wide variety of siliceous or aluminous materials may be pozzolanic. In this leaflet only those of widespread availability will be discussed. Pozzolanas can be divided into two groups: natural pozzolanas such as volcanic ash and diatomite, and artificial pozzolanas such as calcined clays, pulverized fuel ash and ash from burnt agricultural wastes. Pozzolanas can be used in combination with lime and/ or OPC. When mixed with lime, pozzolanas will greatly improve the properties of lime-based mortars, concretes and renders and, in this form, can be used in a wide range of building applications. Alternatively, they can be blended with OPC to reduce costs considerably and to improve certain characteristics of OPC-based concretes, such as long-term strength, resistance to sulphate attack and workability.

Ash from agricultural wastes

Many plant ashes have a high silica content and are therefore suitable as a pozzolana. In recent years considerable research has gone into identifying plant wastes whose ashes produce good pozzolanas and which are available in exploitable quantities.

1. sugar cane bagasse ash, a waste product after electricity production by burning its dry bagasse.
2. Rice husk, a waste product of rice milling has been shown to have the greatest potential.
3. wood ash

Chemical requirements

The material as pozzolona shall conform to the chemical requirements given Table 1as per IS 3812-1981.

Table 1. Chemical requirements of Pozzolona

Sl no	CHARACTERISTIC	REQUIREMENT
1.	Silicon dioxide (SiO2) plus aluminium oxide (Al_2O_3) 70-0 plus iron oxide (Pe $_2O_3$) percent by mass, Min	70.0
2	Silicon dioxide (SiO_2), percent by mass, Min	35.0
3	Magnesium oxide (MgO), percent by mass, Max	5.0
4	Total sulphur as sulphur trioxide (SO_3), percent by mass, Max	2.75
5	Available alkalis as sodium oxide (Na_2O), percent by mass, Max	1.5
6	Loss on ignition, percent by mass, Max	12.0

Materials

Cement: The most common cement is used is ordinary Portland cement. Out of the total production, ordinary Portland cement accounts for about 80-90 percent. Many tests were conducted to cement some of them are consistency tests, setting tests, soundness tests, etc.

Sugarcane bagasse ash:

Sugarcane production in India is over 300 million tons/year that cause about 10 million tons of SCBA as un-utilized and waste. The sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicellulose 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. In this

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sugarcane bagasse ash was collected during the cleaning operation of a boiler.

Table 2. Composition of Sugarcane Bagasse ash

COMPONENT	MASS%
SiO_2	78.34
Al_2	8.55
Fe_2O	3.61
CaO	2.15
Na_2O	0.12
K_2O	3.46
MnO	0.13
TiO_2	0.50
BaO	<0.16
P_2O_5	1.07
LOSS OF IGNITION	0.42

Rice Husk ash:

Rice husk, basically agricultural residue, is obtained from rice processing mills of the developing countries. About 10^8 tonnes of rice husk is generated annually in the world . Meanwhile, the ash has been categorized under pozzolana, with about 67-70% silica and about 4.9% and 0.95% Alumina and iron oxides, respectively. The silica is substantially contained in amorphous form, which can react with the CaOH librated during the hardening of cement to further form cementations compounds. Only a small amount of produced husk is used as fuel in rice mill and electricity generating power plant. After burning rice husk, the RHA is produced as a by-product, about 20% of its original Weight . The unburnt rice husk contains about 50% cellulose, 25-30% of lignin and 15-20% of silica; burning the former two components leaves behind silica ash .When rice husk is burnt at temperatures lower than 700°C, it shows a cellular microstructure which is highly reactive. RHA is a highly pozzolanic material; it contains non-crystalline silica and high specific surface area that are accountable for its high pozzolanic reactivity. The high silica content in the form of non-crystalline or amorphous silica of RHA is dependent on the burning temperatures.

Table 3. Composition of Rice Husk ash.

COMPONENT	MASS%
SiO_2	78.21
Al_2	0.94
Fe_2O	0.37
CaO	0.9
Na_2O	0.12
K_2O	1.815
MgO	4.89
BaO	0.13
P_2O_5	1.17
LOSS OF IGNITION	7.12

Wood ash:

Wood ash is obtained from the combustion of wood. It can be related to fly ash since fly ash is obtained from coal, which is a fossilized wood. Rice husk ash is also of plant origin. This implies that wood ash could be used as a pozzolana in concrete. Tarun, Rudolph and Rafat reported the following elements in wood ash: carbon (5% to 30%), calcium (5% to 30%), carbon (7% to 33%), potassium (3% to 4%), magnesium (1% to 2%), phosphorus (0.3% to 1.4%) and sodium (0.2% to 0.5%). The following compound composition limits were also reported: SiO2 (4% to 60%), Al2O3 (5% to 20%), Fe_2O_3 (10% to 90%), CaO (2% to 37%), MgO (0.7% to 5%), TiO2 (0% to 1.5%), K2O (0.4% to 14%), SO3 (0.1% to 15%), LOI (0.1% to 33%), moisture content (0.1% to 22%), and available alkalis (0.4% to 20%). The study revealed that all the major compounds present in wood ash are present in fly ash.

The wood ash used in this work was powdery, amorphous solid, sourced locally, from a bakery in Minna

Table 4. Composition of Wood ash

COMPONENT	MASS%
SiO_2	31.8
Al_2	28
Fe_2O	2.34
CaO	10.53
NaO	6.5
K_2O	10.38
MgO	9.32
P_2O_5	1.17
LOSS OF IGNITION	27

Experimental procedure

Fresh concrete tests:

In this experimental procedure,the preliminary tests were done for the these agro waste pozzolonas such as specific gravity, consistency, setting time etc.,the specimens of conventional concrete and with partial replacement for cement were casted and tested for their strengths.

The preliminary test for the agro wastes should be done according to **IS : 1727 – 1967.**

Table 5. Properties of Agro wastes.

TEST CONDUCTED	TEST RESULT		
	SCBA	RHA	WA
CONSISTANCY %	38	40	33
SPECIFIC GRAVITY	1.99	2.139	2.13
INITIAL SETTING TIME	195	195	218

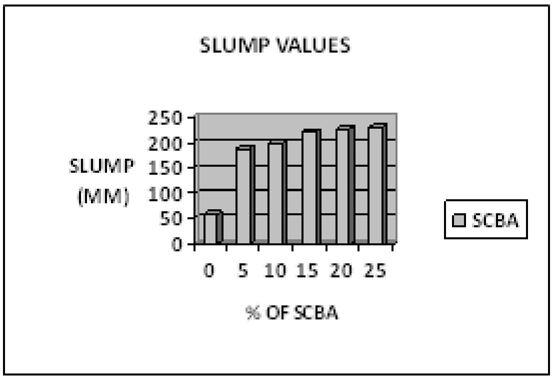
Slump values:

SCBA

Table 6. Slump values of SCBA

Sample Designation	CVC	S1	S2	S3	S4	S5
% of SCBA	0	5	10	15	20	25
Slump (mm)	60	187	200	220	225	230

Figure 1. % of SCBA Vs Slump

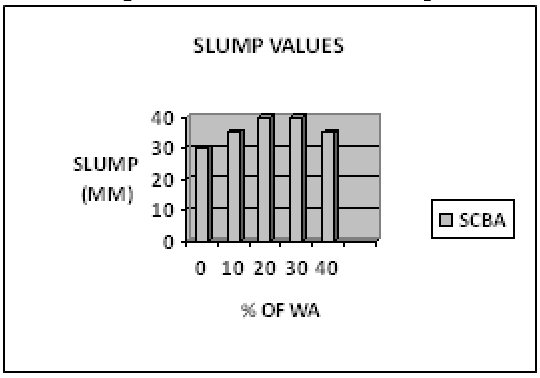


2. WOOD ASH

Table 7. Slump values of WA.

Sample Designation	CVC	W1	W2	W3	W4
% of SCBA	0	10	20	30	400
Slump (mm)	30	35	40	40	35

Figure 2. % of WA Vs Slump.



Hardened concrete tests:

Suitable specimens were casted for compressive strength, split tensile strength and flexural strength for conventional concrete and for various replacement percentages of cement by SCBA ,RHA , WA. The specimens are cured for 28 days strength and tested according to standards.

1. SCBA

Table 8. Results of SCBA concrete at 28 days

Sample Designation	CVC	S1	S2	S3	S4	S5
% of SCBA	0	5	10	15	20	25
Compressive Strength (MPa)	21.27	29.50	24.70	19.32	18.85	17.73
Split Tensile Strength (MPa)	1.526	1.94	1.59	1.45	1.34	1.24
Flexural Strength (MPa)	3.46	3.74	3.56	3.38	3.18	3.02

Figure 3. % of SCBA Vs Compressive strength

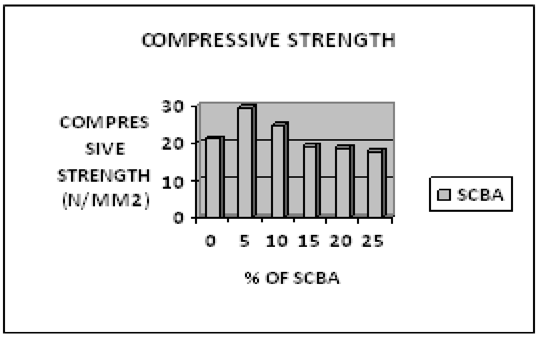


Figure 4. % of SCBA Vs Split tensile strength

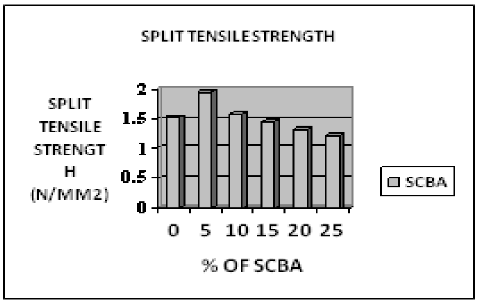
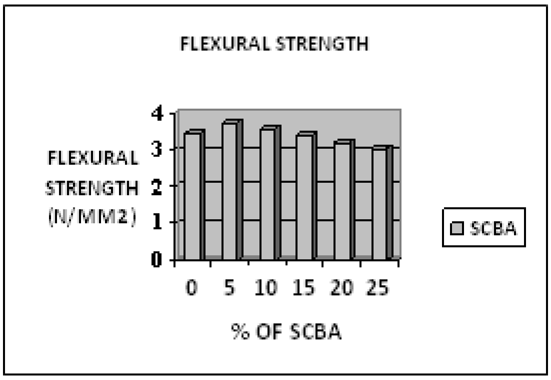


Figure 5. % of SCBA Vs Flexural strength



2. RHA

Table 9. Results of RHA concrete at 28 days

Sample Designation	CVC	S1	S2	S3	S4
% of RHA	0	5	10	15	20
Compressive Strength (MPa)	40.00	31.25	35.8	32.3	34
Split Tensile Strength (MPa)	4.2	4.8	5.8	6.51	2.69
Flexural Strength (MPa)	9	10.4	8.8	9.6	8

Figure 6. % of RHA Vs Compressive strength

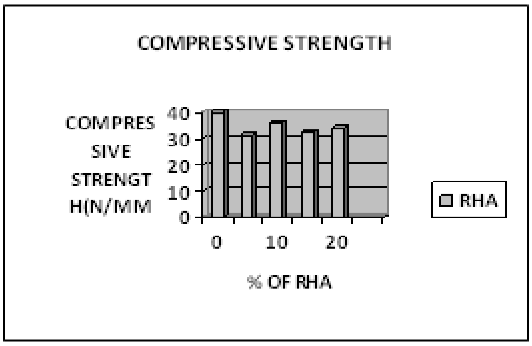


Figure 7. % of RHA Vs Split tensile strength

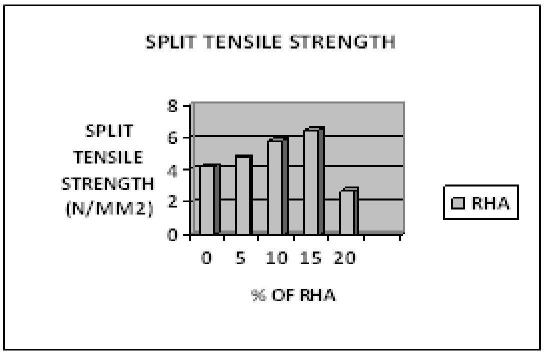
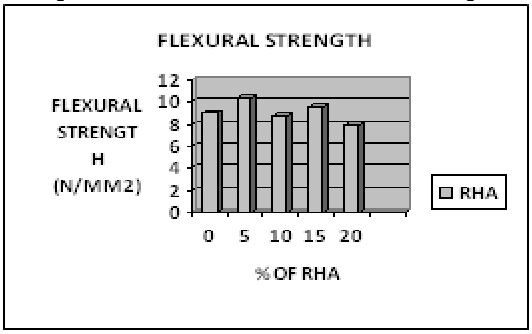


Figure 8. % of RHA Vs Flexural strength

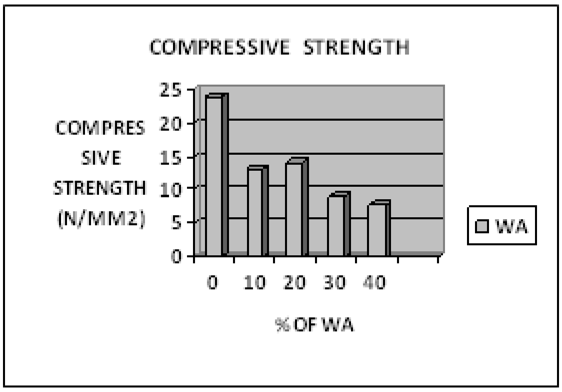


WOOD ASH (WA).

Table 10. Results of WA concrete at 28 days

Sample Designation	CVC	W1	W2	W3	W4
% of WA	0	10	20	30	40
compressive strength (N/mm2)	23.96	13.09	14.13	9.02	7.82

Figure 9. % of WA Vs Compressive strength



Conclusions

1. SCBA:

1. .The results show that the SCBA in blended concrete had significantly higher compressive strength, tensile strength, and flexural strength compare to that of the concrete without SCBA.
2. It is found that the cement could be advantageously replaced with SCBA up to maximum limit of 10%. Although, the optimal level of SCBA content was achieved with 1.0% replacement.
3 .Partial replacement of cement by SCBA increases workability of fresh concrete; therefore use of super plasticizer is not substantial.
4 .The density of concrete decreases with increase in SCBA content, low weight concrete produced in the society with waste materials (SCBA).

2. RHA:

1. Compressive strength increases with the increase in the percentage of Rice Husk Ash up to addition of 10% by weight of cement.
2. Concrete requires approximate increase in water cement ratio due to increase in percentage of RHA. Because RHA is highly porous material.
3. The workability of RHA concrete has been found to decrease with increase in RHA replacement.
4. It was found that rice husk when burned produced amount of silica (more than 80%). For this reason it provides excellent thermal insulation.
5. Rice husk ash contains more silica, and hence we prefer rice husk ash use in concrete to increase the strength.
6. Though Rice husk ash is harmful for environment, but the cost of rice husk ash is zero and thus we prefer RHA use in concrete as compared to silica fumes.

3. WOOD ASH:

1. The water requirement increases as wood ash content increases.
2. The setting times of wood ash / OPC paste increases as the ash content increases; the 10% and 20% wood ash paste satisfy the recommended standard for ordinary Portland cement paste. 30% and 40% wood ash paste gave higher values of setting times which do not satisfy the standard.
3. The compressive strength of the concrete with 20% wood ash content increased appreciably at 28 days. The optimum replacement level was therefore 20%.

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