Original Article

A Review On Agrarian-Residues As A Partial Replacement Of Cement In Concrete

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Abstract

Cement is the most expensive constituents of concrete. An expanding amount of exploration on the utilization and implementation of agricultural, industrial and thermal power stations leftover within the fabrication of concrete has seen. In this review, the potential of Corncob ash (CCA), Rice husk ash (RHA), Sawdust ash (SDA), Sugarcane bagasse ash (SCBA) powder used as an alternate Supplementary cementitious material in concrete and enhancing the trimming of these squanders and reducing the expense of concrete manufacture by making use of locally accessible resources. The mechanical and physical properties were examined and compared. Supplementary cementing materials are added to concrete with (0%, 5%, 10%, 15%, 20%, and 25%) by weight of OPC. Specimens were prepared and tested at the curing ages of 7, 14, 21, 28, and 56 days respectively. The outcomes displayed that the compressive strength diminishes with an increasing percentage of partial replacements but increases with curing. Workability decreased upon the inclusion of RHA, CCA, SDA and SCBA. Only the ten percent replacement of Ordinary Portland Cement (OPC) with agro-waste in cement could be worthy to appreciate the utmost strength acquire. As we are aware that the construction industry is a source of environmental degradation being in the era and generation that needs to act on environmental issues, introducing the agricultural wastes is a beneficial step paving the way for waste management with cost-effective procedures and promoting better air quality.

Keywords: Compressive strength, Corncob ash (CCA), Rice husk ash (RHA), Sawdust ash (SDA), Sugarcane bagasse ash (SCBA), Workability.

INTRODUCTION

Over the past decennium, the rapid industrialization and increase in the curve of the population have paved the way for the construction industry. Concrete is being the oldest and most common material used for construction. It is a blended material bound with coarse aggregate, fine aggregate, water and ordinary Portland cement (OPC), which is the binding agent of all the materials to mix [1]. It was invented by Joseph Aspdin of Leeds, Yorkshire, England, in 1824. The cement yield rate of the world is on the brink of 4.2 billion tones in 2019. It is expected to be more in the coming years. China stood first with about 55% of global production and followed by India with 8%. During the fabrication of cement, a large amount of CO2 is released, which causes global effects. Cement contributes about 8% of the world's carbon emissions. To decrease the ill Agrarian residues as a partial replacement of cement in concrete effects of concrete in the environment, the utilization of sustainable products is way beneficial (Olafusi and Olutoge, 2012). As the world has continuous growth of by-products arising from agriculture, the construction industry has identified and use the by-products as a filler in concrete which has pozzolanic properties like Rice husk ash (RHA), Corncob ash (CCA), Sawdust ash (SDA), Sugarcane bagasse ash (SCBA) and Sawdust ash (SDA)which helps in reducing the carbon emissions (Olafusi and Olutoge, 2012; Adesanya and Raheem, 2009). Rice husk is the hard protective layer of rice grains which is separated by grains during milling, which contains 30%-60% of organic carbon. Rice husk is wealthy in (SiO2) silicon dioxide, which makes it extremely responsive with (Cao) lime because of its non- crystalline silica content and its particular surface. Initially, the rice husk is burnt and converted into ash by an open heap burning technique between 400 to 6000c for about 24 hours (Abdul Rahim et al., 2015; Ephraim et al., 2012; Shukla et al., 2011). Sawdust is the by-product of wood, and it is obtained by working operations like sawing, milling, planning and routing. The timber industry produces a large number of heaps of sawdust as this process repeats daily; it can also be collected in hemorrhoids. The sawdust is burnt and converted into ashes by slash and burn technique during a metal vessel (Raheem et al., 2012) Corn is consumed by a large number of population and a major component of livestock feed. Corn cob is that the outgrowth acquired from corn or maize, is the focal center of corn. Cobs are cut into pieces and dried for one week, then burnt in the furnace at about c up to 48 hours (Suwanmaneechot et al., ; Ettu et al., 2013) Bagasse is an outgrowth of the sugar industry; it is the waste produced from sugarcane after juice extraction. Nearly 3 tons of bagasse are produced from 10 tons of crushed sugarcane. Bagasse is utilized as an essential material for papermaking in the view of its stringy surface. Around 0.3 huge loads of paper can be produced using 1 ton of bagasse. The bagasse is burnt at 6500c for about 48 hours and converted into ash (Amin, 2011; Ganesan et al., 2007). The relevant use of these agricultural by-products in concrete not only improves its strength but also promotes the sustainable method of re-utilization of agricultural residue when leftover would pollute land, air and water. As these materials contain pozzolanic properties, these can be replaced with some part of the cement (Adesanya and Raheem, 2009; Zareei, 2018)

Materials and Methods

Materials:

Ordinary Portland cement (OPC): OPC is synthesized by blending limestone; few raw materials, which consist of argillaceous, calcareous and gypsum, are the most commonly used material and preferred during urgent constructions. Portland cement generally available in the market with three grades like 33, 43 and 53. These grades insinuate the maximum strength after 28 days (Abdul Rahim et al., 2015; Leong, 2015). Portland cement is a composite fusion of main compounds like, Silicon dioxide (SiO2), Calcium oxide (Cao), Aluminum trioxide (Al2O3), and Iron oxide (Fe2O3). Additionally, to those amalgams, it likewise comprises modest measures of magnesium oxide (MgO) along with oxides of the alkali metals such as sodium (Na2O) and potassium (K2O).

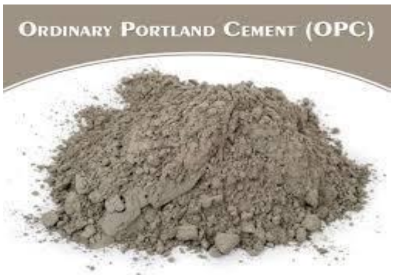


Figure 1 Ordinary Portland cement

Table 1 Chemical Configuration of Ordinary Portland cement (OPC) (Abdul Rahim *et al.* 2015)

CONSTITUENTS	PERCENTAGECOMPOSITION(%)
Calcium oxide (Cao)	63.61
Silicon dioxide (Sio2)	20.25
Aluminum trioxide Al2o3)	5.04
Iron Oxide (Fe2o3)	3.16
Magnesia (Mgo)	2.46
Sulphur Trioxide (So3)	2.69
Potassium Oxide (K2o)	0.51
Sodium Oxide (Na2o)	0.08
Loss of Ignition	1.98

Aggregates: Aggregates are by-products obtained by crushing rocks within the quarries. These are two types, namely coarse and fine aggregates. The aggregates got to be sieved utilizing the mechanical sieve shaker prior to blending in with other material. The coarse aggregate's extreme size is 20mm, while the dimension of the fine aggregate is smaller amount than mm. Coarse aggregate acts as an inert filler in concrete, whereas fine aggregate fills the voids existing within the coarse aggregate (Leong, 2015; Kumar et al., 2016).

Water: Water is an essential ingredient while at the same time converging with concrete; it frames a glue that ties the blend. Water helps in solidifying of the concrete through a cycle called hydration. The proportion of water in concrete, controls many properties like workability, compressive strength, permeability, durability and weathering. Water utilized in this research is from the faucet water available within the laboratory (Leong, 2015).

Rice husk ash (RHA): Rice husk is that the hard protecting layer of rice grains which might be isolated by grains during milling it's burnt for approximately 24 hours in open heap technique under controlled burning process by ranging the temperature from 400-6000c, which is collected undergoes grinding and sieved through IS sieve size 75µm (Ephraim et al., 2012; Zareei et al., 2017). The investigation of the ash is regulated by means of X-ray Fluorescence Analyzer. The chemical configuration of RHA is introduced in Table 2.

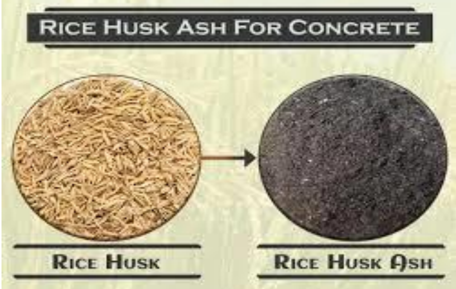


Figure 2 Rice husk Ash

Table.2 Chemical Configuration of Ricehusk ash (RHA) (Ganesan *et al*., 2008)

CONSTITUENTS	PERCENTAGE COMPOSITION(%)
Lime (Cao)	0.48
Silica (Sio2)	87.32
Alumina (Al2o3)	0.29
Iron oxide (Fe2o3)	0.38
Magnesia (Mgo)	0.27
Sulphur Trioxide (So3)	0.86
Potassium Oxide (K2o)	3.14
Sodium Oxide (Na2o)	1.02
Loss of Ignition	4.19

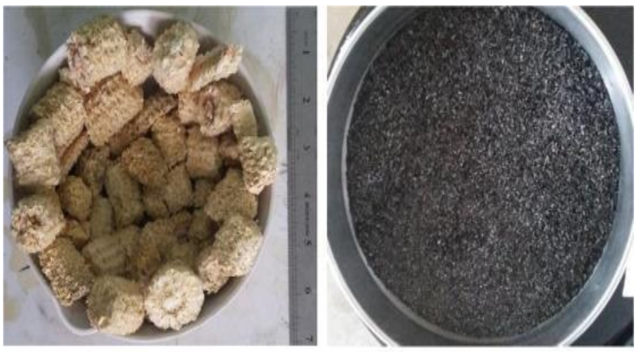
Sawdust ash: Sawdust is that the spinoff of timber obtained by working tasks like sawing, milling, planning and routing, which is burnt and changed over into ash by open flaming during a metal vessel about the temperature of 6000c. Then it is ground after cooling and sieved through IS sieve size 75µm (Elinwa and Mahmood, 2002; Udoeyo and Dashibil, 2002; Marthong, 2012)The investigation of the ash is regulated by means of X-ray Fluorescence Analyzer. The chemical configuration of SDA is introduced in Table 3.

Figure 3 Saw Dust Ash

Table 3 Chemical Configuration of Sawdust ash (SDA) (Elinwa and Mahmood, 2002)

CONSTITUENTS	PERCENTAGE COMPOSITION(%)
Lime (Cao)	9.98
Silica (Sio2)	67.20
Alumina (Al2o3)	4.09
Iron Oxide (Fe2o3)	2.26
Magnesia (Mgo)	5.80
Sulfite (So3)	1.33
Potassium Oxide (K2o)	3.87
Sodium Oxide (Na2o)	0.07
Loss of Ignition	5.16

Corncob ash: Corncob is the offshoot acquired from corn or maize is that the central core of corn which are crushed into small pieces and dried under the sun for one week. The dried corn is burnt for approximately 48 hours in an Open-air furnace at a controlled temperature of 6500C, which is cooled for 2days and crushed into ash, is sieved through IS sieve size 150µm (Olafusi and Olutoge, 2012; Adesanya and Raheem, 2009) The investigation of the ash is regulated by means of X-ray Fluorescence Analyzer. The chemical configuration of CCA is introduced in Table 4.



(a) (b)

Figure 4 Corn Cob Ash

Table 4 Chemical Configuration of Corncobash (CCA) (Adesanya and Raheem, 2009)

CONSTITUENTS	PERCENTAGE COMPOSITION(%)
Lime (Cao)	11.57
Silica (Sio2)	66.28
Alumina (Al2o3)	7.41
Iron Oxide (Fe2o3)	4.46
Magnesia (Mgo)	2.05
Sulphur Trioxide (So3)	1.04
Potassium Oxide (K2o)	4.97
Sodium Oxide (Na2o)	0.41
Loss of Ignition	1.59

Sugarcane bagasse ash (SCBA):

Bagasse is an outgrowth of the sugar industry; it's the residue of sugarcane after juice extraction, which is dried under the sun for 2days. The dried bagasse is burnt for approximately 48 hours in a closed drum for about 6500c, is ground after cooling and sieved through IS sieve size 150µm (Ganesan et al., 2008 ; Ganesan et al., 2007) The examination of the ash is regulated by means of X-ray Fluorescence Analyzer. The chemical configuration of SCBA is introduced in Table 5.

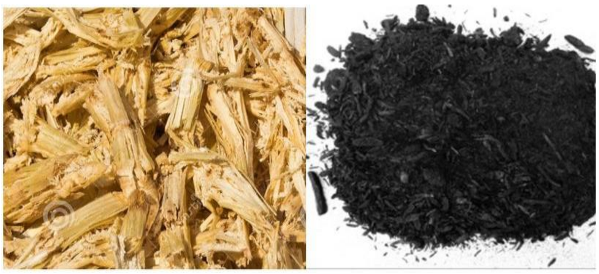


Figure 5 Sugarcane Bagasse Ash

Table 5 Chemical Composition of Sugarcane bagasse ash (SCBA) (Ganesan *et al*., 2007)

CONSTITUENTS	PERCENTAGE COMPOSITION (%)
Lime (Cao)	8.17
Silica (Sio2)	64.23
Alumina (Al2o3)	9.08
Iron Oxide (Fe2o3)	5.47
Magnesia (Mgo)	2.97
Sulphite (So3)	0.87
Potassium Oxide (K2o)	1.32
Sodium Oxide (Na2o)	0.87
Loss of Ignition	6.25

Methods: Compressive strength test: Compressive strength, the ability of a material when a force is applied to the top and bottom of a test sample until the sample is breaks or deformed. Specimen preparation for compressive strength test is cube-shaped and moulded with dimensions of 150mm x 150mm x 150mm. The samples are divided into batches with 0%, 5%, 10%, 15%, 20%, 25% replacement by weight of OPC with RHA, SDA, CCA, and SCBA. These samples were subjected into moulds for specimen preparation and covered with wet gunny bag and left uninterrupted for 24 hours at a temperature of 27±20c with 90% relative humidity. After 24 hours these cubes were removed from moulds and are placed in freshwater for 7, 14, 21, 28, 56 days respectively for curing. Water needs to be changed for every seven days. The cubes are required to be removed from the water approximately 30 minutes prior to the testing and undergo surface drying. The compressive strength of cubes can be determined with reference to the replacement by supplementary cementing materials and curing ages, by placing the specimens in the Universal testing machine, which has a maximum capacity of kN.

Slump test: Workability of concrete is the property of freshly mixed concrete that implies the ease and homogeneity by which concrete is mixed, placed, consolidated and finished. Slump is carried out to check the effect of RHA, SDA, CCA, and SCBA on the workability of concrete. This test is carried out under the requirements of IS: 7320 – 1974. The difference in height of slump cone and sample gives the value of slump.

Splitting tensile test: It is the tensile strength of concrete obtained by applying a compressive force along the length of the cylinder. Specimen preparation for the Split tensile test is cylindrical shaped and moulded with dimensions of 150mm in diameter and 300mm in length. The samples are divided into batches with 0%, 5%, 10%, 15%, 20%, 25% replacement by weight of OPC with RHA, SDA, CCA, and SCBA. These samples were subjected to moulds for specimen preparation and left undisturbed for 24 hours at a temperature of 27±20c with 90% relative humidity. After 24 hours these cylinders were removed from moulds and are placed in freshwater for 7, 14, 21, 28, 56 days respectively for curing. Water needs to be changed for every seven days. The cylinders are required to be removed from the water approximately 30 minutes prior to the testing and undergo surface drying. The Split tensile strength of cylinders can be determined with reference to the replacement by supplementary cementing materials and curing ages, by placing the specimens longitudinally in the Universal testing machine, which has a maximum capacity of 2000kN.

Results and Discussion:

Physical properties: The samples were dark-colored with the expanding percentage of corn cob ash and accordingly the setting time and water absorption took for much longer in concretes with the ash content than those without the ash. The outcome from the most part revealed density increased as curing age increased and diminished concerning the expanding level of corn cob ash replacement in concrete samples (Olafusi and Olutoge, 2012).

Table 6 Density of the cubes(x10^3kg/m^3) (Olafusi and Olutoge, 2012)

Replacement(%)	Curing ages			
	7 days	14 days	21 days	28 days
0	2.5	2.56	2.62	2.65
10	2.47	2.51	2.56	2.48
20	2.39	2.40	2.42	2.42

Ordinary Portland cement (OPC) of 43 grade is taken and performed tests for specific gravity, consistency, initial setting and final setting time. The outcomes of the tests associated with the tolerable limits of IS code :2009. The initial and final setting time of cement was 190 minutes and 345 minutes, respectively. The specific gravity of cement is Similarly the specific gravity, fineness modulus and moisture content of fine and coarse aggregates are tested (Kumari et al.)

Table 7 (Kumari *et al.*)

Material	Specificgravity	Finenessmodulus	Moisturecontent
Fine aggregate	2.69	2.64	1.64
Coarse aggregate	2.703	2.89	1.37

Early and final setting times of samples with Corncob ash (CCA) replacement and observed that all the sample fulfill the NIS:2000 requirement of 45 minutes minimal initial setting time and maximum of 10 h final setting time (Suwanmaneechot et al., 2015)

Table 8 (Suwanmaneechot et al., 2015)

Sample	Replacemt (%)	Normal Consistency (%)	Initial settingtime (minutes)	Final settingtime (minutes)
CCA	0	26.84	115	223
	5	28.80	183	314
	10	30.98	222	349
	15	34.05	252	387
	20	35.77	271	405

The ordinary Portland cement of 53 grade was observed to have the normal consistency of 32% with a specific gravity of 3.15. The fineness of cement was 2.33 which had the initial setting time of 45 minutes and final setting time as 583 minutes and the soundness test of cement as 3mm. The specific gravity of fine aggregate is in a reach between 2.6 to 2.9. The specific gravity of coarse aggregates utilized is 2.427 and 2.474 (Kumar et al., 2016). The physical properties of ordinary Portland cement and sugarcane bagasse Ash and found the specific gravity as 3.15 and 2.12, respectively. The initial setting time and final setting time of ordinary Portland cement as 115 minutes and 229 minutes (Reddy et al., 2015). The compacted bulk density of ordinary Portland cement and bagasse ash as and 0.59 and loose bulk density as 1.16 and 0.41 with a specific gravity of 3.1 and 1.85, respectively. The fineness is observed as 85 and with a specific surface of 326 and 943 (Ganesan et al., 2007). The physical properties of high- strength Portland cement and bagasse ash which had a density of 1.15 and 0.4, respectively. The specific gravity was found to be 3.0 and 1.80 with fineness passing of 82 and the specific surface area was found to be 300 m and 900 with a mean grain size of 21 and 5.1 µm (Amin, 2011). The physical properties of Sawdust ash, such as the moisture content to be 0.45% with a specific gravity of 1.15 and loss on ignition as 8.4. The pH was found to be 9.5 (Udoeyo and Dashibil, 2002)

Mechanical properties: Compressive Strength test: Table 9 describes the observed values of compressive strength of different agricultural wastes at various curing ages with percentage of partial replacement found by numerous authors. The outcomes uncover that the sugarcane bagasse documented great outcomes contrasted with some other materials however all the materials can be utilized as substitution as the strength increases with increment in curing age.

Table 9 Compressive Strength test

S.NO	Name of the Author	Sample	Curingages (days)	Compressive Strength N/mm^2				
				Percentage(%) of replacement				
				0	5	10	15	20
1.	Mujedu *et al.*, (2014)	Corncob ash(CCA) and Sawdust ash(SDA)	7	15.37	-	14.06	-	12.71
			14	18.14	-	16.15	-	13.03
			21	19.43	-	17.32	-	14.95
			28	23.55	-	20.07	-	15.84
2.	Olafusi and Olutoge *et al.*, (2012)	Corncob ash(CCA)	7	14.67	-	13.18	-	9.18
			14	18.96	-	15.41	-	10.16
			21	21.04	-	19.41	-	12.74
			28	21.69	-	20.00	-	13.78
3.	Kumari, *et al*	Corncob ash(CCA)	7	17.45	13.41	12.13	-	-
			14	20.44	19.59	18.79	-	-
			21	-	-	-	-	-
			28	21.51	26.81	25.15	-	-
4.	Suwanmaneechot *et al.*, (2015)	Corncob ash(CCA)	7	26.12	26.95	29.83	30.00	25
			14	33.14	29.98	34.87	36.12	33.13
			21	-	-	-	-	-
			28	37.50	34.61	41.12	40.00	35.17
5.	Ettu *et al.*, (2013)	Corncob ash(CCA)	7	14	9.40	8.00	7.10	-
			14	21.50	18.70	14.50	10.90	-
			21	22.10	21.20	16.00	13.00	-
			28	23.00	22.10	19.30	16.00	-
6.	Abdul Rahim *etal.*, (2015)	Rice husk ash (RHA)	7	21.86	20.15	-	18.04	15.54
			14	25.10	21.52	-	21.25	20.33
			21	-	-	-	-	-
			28	27.15	25.24	-	24.46	24.24
7.	Ephraim *et al.*, (2012)	Rice husk ash (RHA)	7	-	-	12	-	10
			14	-	-	14	-	12
			21	-	-	18	-	14
			28	-	-	22	-	19
8.	zareei *et al.*,(2017)	Rice husk ash (RHA)	7	50.84	51.92	53	56.43	56.67
			14	-	-	-	-	-
			21	-	-	-	-	-
			28	83.36	85.12	86.9	92.51	93.28
9.	Ganesan *et al.*, (2008)	Rice husk ash (RHA)	7	27.2	27.6	28.00	29.30	29.70
			14	32.3	34.20	35.30	36.00	39.30
			21	-	-	-	-	-
			28	37.1	40.00	41.30	41.80	42.50
10.	Givi *et al.*, (2010)	Rice husk ash (RHA)	7	27.3	25.7	25.1	23.7	2.5
			14	-	-	-	-	-
			21	-	-	-	-	-
			28	36.8	38.7	40.6	37.9	36.7
11.	Raheem *et al.*, (2012)	Sawdust ash(SDA)	7	15.00	14.52	14.21	11.12	10.10
			14	-	-	-	-	-
			21	-	-	-	-	-
			28	22.4	15.00	14.30	11.67	12.31
12.	Elinwa and Mahmood, (2002)	Sawdust ash(SDA)	7	17.63	13.91	13.11	8.98	7.96
			14	21.74	19.65	16.00	12.00	9.47
			21	-	-	-	-	-
			28	23.12	21.6	18.14	15.74	11.52
13.	Udoeyo and Dashibil, (2002)	Sawdust ash(SDA)	7	18.51	-	17.82	15.31	13.50
			14	-	-	-	-	-
			21	-	-	-	-	-
			28	25.24	-	24.25	18.97	15.26
14.	Amin, (2011)	Sugarcane bagasse ash(SCBA)	7	27	30	35	35	35
			14	-	-	-	-	-
			21	-	-	-	-	-
			28	36	42	43	42	40
15.	Ganesan *et al.*, (2008)	Sugarcane bagasse ash(SCBA)	7	27.5	31.5	34.41	34.10	34.00
			14	32.5	34.45	41.63	40.87	39.11
			21	-	-	-	-	-
			28	36.5	41.90	42.51	41.23	40.23
16.	Reddy *et al.*, (2015)	Sugarcane bagasse ash(SCBA)	7	35	39	37.5	35.5	31.66
			14	-	-	-	-	-
			21	-	-	-	-	-
			28	41.05	45.33	51.3	48.5	44.83

Slump test: **Table 10** describes the observed values of slump test of different agricultural wastes at various percentage of partial replacement found by numerous authors. The results reveal the sawdust recorded great outcomes contrasted with some other materials anyway all the materials can be utilized as a substitution incement.

Table 10 Slump Test

S.No	Name of the Author	Sample	Percentage(%) ofreplacement	Slump(mm)
1.	Mujedu *et al*., (2014)	Corncob ash (CCA) and Sawdust ash(SDA)	0	100
			5	96
			10	90
			15	87
			20	83
2.	Kumari, *et al*	Corncob ash (CCA)	0	70
			5	62
			10	60
			15	57
			20	54
3.	Suwanmaneechot *etal*., (2015)	Corncob ash (CCA)	0	102
			5	104
			10	98
			15	90
			20	87
4.	Abdul Rahim *et al*., (2015)	Rice husk ash (RHA)	0	48
			5	40
			10	43
			15	45
			20	35
5.	Raheem *et al*., (2012)	Sawdust ash (SDA)	0	110

Splitting tensile strength test:

Table 11 describes the observations of splitting tensile strength found by various authors on the percentage of replacement with respective husk documented great outcomes contrasted with some other materials however all the materials can be utilized as substitution as the strength increases with increment in curing age.

Table 11: **Splitting tensile strength test**

S.NO	Name of theAuthor	Sample	Curingage (days)	Splitting tensile Strength (Mpa)				
				Percentage (%) of replacement				
				0	**5**	**10**	**15**	**20**
1.	Suwanmaneechot *et al*., (2015)	Corncob ash(CCA)	28	4.2	4.2	4.1	4.3	3.8
2.	zareei *et al*.,(2017)	Rice husk ash(RHA)	28	5.83	5.95	6.08	6.47	6.52
3.	Udoeyo and Dashibil, (2002)	Sawdust ash(SDA)	28	2.80	2.79	2.76	2.69	2.61
4.	Amin, (2011)	Sugarcane bagasse ash (SCBA)	28	4.5	4.9	5	4.9	4.5

Conclusions:

- Concrete compressive strength gains with curing time and diminishes with increasing percentage of partial replacements.
- • The partial replacement of cement with agricultural wastes is a beneficial step paving a way for waste management with cost effective procedures.
- • The usage of RHA, CCA, SDA and SCBA in concrete is not only a waste-minimizing technique; also it saves the amount of cement.
- At initial ages, the percentage increase of replacement of agricultural wastes is directly proportional to compressive strength.
- Setting time increased with increasing extents of RHA, CCA, SDA and SCBA substitutions.
- Incorporation of the agricultural wastes enhanced the achievement of lightweight concrete quite the opposite concrete types.
- The strengths of agricultural waste replacements depend on its pozzolanic activities.
- The materials RHA, CCA, SDA and SCBA, are satisfactory for use as a pozzolan since they fulfilled the need for materials by having a combo (SiO_2 +Al_2O_3 +Fe_2O_3) of quite 70%.

- Workability decreased upon the inclusion of RHA, CCA, SDA and SCBA. Thus, blends containing these require excessive water content than the corresponding control mixes.
- Utilities of additives to cement can serve to make mechanical and pro-mechanical aspects which will be a source of biological and economic benefits.
- • Only the ten-percentile substitution of Ordinary Portland cement with agro wastes in concrete would be admissible to appreciate greatest benefit of strength gain.
- It is observed that the usage of agro wastes in concrete helps in increasing the resistivity towards sulphate attack.\

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