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EFFECT OF AGRO WASTE ASH ON THE PROPERTIES OF RECYCLED COARSE AGGREGATE CONCRETE

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ABSTRACT

In this paper presents the mechanical and microstructure of Effect of Agro waste ashes on the properties of recycled coarse aggregate concrete incorporating rice straw ash and cotton stalk ashes as a replacement ratio by the weight of cement content , Recycled coarse aggregates were replaced by the ratio(RCA) by the weight of natural coarse aggregates. Seven mortar mixes are prepared with Rice straw ash (RSA) and cotton stalk ash(CSA). Three mixes are used with 5%,10% and 15% RSA and remaining Three mixes are used with 5%,10% and 15% of CSA. These seven mixes are casted for 28 days compressive test is conducted and we get high performed percentage mixes are CSA 10% and RSA 5%. The recycled coarse aggregates (RCA) is used as a replacement of normal weight coarse aggregates with a ratio of 70%.

Key words: Recycled coarse aggregates (RCA),Rice straw ash (RSA),Cotton stalk ash (CSA),concrete, mechanical properties and durability properties.

1.INTRODUCTION

Agriculture waste ash is produced via replacement with coal and fossil fuels to produce the necessary energy to operative factories [1].the global energy production from agriculture waste is approximately 9% of the totral energy [2].In generally, these agriculture wastes are set on fire in the fields by the farmers and then their ash disposed in landfills or water bodies near by ,the advancements in research on ashes that are produced as a result of combustion of agricultural waste have resulted in identifying usability of such waste materials in the fields of civil engineering and especially in concrete technology[3-6].

Many agriculture residues and waste ash are available: olive stones, straws ,cotton stems. Grape seeds, bagasse[7-10]pine mulch[11] ;almonds ,hazelnuts, sunflower stem , sunflower seed husk,[12-14];oats ,rice hulls and corn [15-18];cherry stones, peaches and apricots[10,17].coconut shell[20].In addition to agricultural waste ashes are used in engineering applications according to their chemical composition and physical properties [21,22].Many researchers have recently focused on studying the use of agricultural ash waste as a partial substitute for cement .using such waste as a partial substitute for cement substantially contributes to reduce global cement consumption. Thus the following is reduced.1)carbon-di-oxide emission resulting from lime stone calcinations during the clinker manufacturing process. Previous studies indicate that cement is the second – largest source of carbon-di-oxide emission through an estimated annual emission of 7% of global emission 2015[23,24],Mean while,CO_2 emission are expected to increase by 4% in 2050.its depending on the forecasts of the International Energy Agency (IEA)[25].2)It takes approximately ,one ton of limestone ,as a raw materials and 3.2 – 6.3 gigajoules of energy mostly derived from fossil fuels to produce one ton of clinker [26,27].The use of supplementary cementing materials (SCM)from agricultural residue ah in the production of cement or concrete mixes provides a suitable option to reduce emission ,and these materials can be partial replacement between 10%Vto 30% mass of the cement based on their pozzolanic content and binding properties [28].Hunt-zinger and Eatmon believed that major refinement and cement production operations will decline in the future due to the environmental risks of cement production operations will decline in the future due to the environmental risks of cement production ,the desire to eliminate agricultural waste and the benefits of these materials to green concrete[29].Several new crops can be added to the list of agricultural wastes, which can be used to replace cement partially ,Ashes of the cotton straw and rice straw ashes and palm leaf can be used as a supplementary materials or as a partial replacement for cement [30].

Concrete is the most widely used building material in the world .is composition contains aggregates ,cement and waster [31],The chemical reaction between these components finally forms a hardened rocks like material, known as concrete. The hardening of the concrete depending on the properties of this components and composition . During the last century ,the ordinary Portland cement ,the conventional aggregates and mild steel as reinforcement have been mainly used to attain the desired durability and utility of concrete. However ,with the changed utilization patterns of these components in light of the boom in real estate sector and continuously depleting aggregate sources ,the researchers for the alternative aggregates materials has become a need of the hour. There is a strong possibility of utilizing the waste material like an agricultural waste as an alternative to aggregates in concrete manufacturing ,if not completely ;at least partially as their disposal constituted to be an environmental challenge[32,33].

The Environmental pollution associated with the aforesaid waste has lead us to think about the necessity to utilize or dispose-off these wastes in a manner so that their ill effects on the living being, flora and fauna may be avoided .After exploring a number of possibilities ,we reached at a conclusion that these may be used as a partial replacement of aggregates in concrete control mix .so many studies being done to investigate their impact on the concrete manufacturing . The durability and compressive strength , and other characteristics along with the workability of this alternative material could be of greater interest of the researchers. This approach exacted t be doubly beneficial; on the one hand ,it will ne a safeguard to the environment, as it will be utilizing the solid waste material of hazardous nature[34].Hence, there is a strong need to search for such ways by which these waste can be used efficiently to reduce their harmful effects on the environmental[35].

The prime motto of this study is to find out whether the waste materials that are harmful to the environment can be used as a substitutes for normal aggregates in concrete and can thus be helpful in developing an alternative building material probably with some improvement in the properties [36].The complete replacement of aggregates by these waste materials is not possible ,therefore ,researchers ,throughout the world, are trying to find out different ways and means for changing the composition of concrete mix to make construction more environment friendly , sustainable and economic with possible improvement in some characteristics, if not all. Number of research groups shown greater interest towards this goal of saving the environment through exploring the possibilities of utilizing the solid waste materials as a substitutes to aggregates in the concrete. Thereby, initiating altogether a new solid waste management practices along with the making the constructions more sustainable ,economic and eco-friendly[37].

In the present study, we have attempted to use these agriculture wastes(such as rice straw ash and cotton stalk ashes) in the concrete mixes and as a partial replacement of coarse aggregates with industrial construction waste (recycled coarse aggregates).total 8 type of mixes are prepared with partial replacement by weight of cement content CSA 10% and RSA 5% ,and RCA are replaced with normal aggregates up to 70%.All eight mixes test specimen of sizes 100mm×100mm×100mm were prepared for testing ,out of these one mix was prepared conventional concrete M35 grade. All the test specimens were cured for 7 days and 28 days under the controlled condition . After 7 days and 28 days all these specimens were tested on the mechanical , durability properties and also micro structural analysis.

2.OBJECTIVE

The main objective of this study to investigate the potential use of RSA and CSA based Recycled Coarse Aggregate concrete as a supplementary Cementous material. RSA and CSA were incorporated in concrete with two different doses are conventional concrete, RSA 5%, CSA 10% by weight of OPC 53 grade, and Recycled aggregate were replaced as a normal aggregates with 0%,10%,20%,30%,40%,50% and 60% .To determine the mechanical and durability properties of Agro waste ashes on the properties of Recycled coarse aggregate concrete concrete.

Mechanical properties were investigated by the following tests.

1.Compressive Strength 2. Split Tensile Strength 3. Flexural Strength

Durability properties were investigated by the following tests.

1. Water absorption ,2. Water permeability test,3.Sorpitivity test ,4. Acid attack,5. Sulphate attack

- To determine the overall environmental effects of concrete production using these materials as partial replacement.
- To minimize the cost of cement by utilize this agricultural wastage of RSA ,CSA and Construction or industrial wastage of Coarse aggregates.

3.EXPERIMENTAL STUDY

A.Materials

The following materials were used for the preparation of the concrete mix

1.Cement
2.Fine Aggregates
3.Coarse Aggregates
4.Rice Straw ash and Cotton Stalk ash
5.Recycled coarse aggregate concrete
6. Water

3.1 Cement

In this project BIRLA-A1 cement of 53 grade was used for all mortar and concrete mixes. The cement was of uniform in colour i.e., grey with a light greenish and was free from hard lumps. Laboratory tests conducted on cement are initial setting time and final setting

time, specific gravity, fineness test ,Blaine's Air permeability test and compressive strength etc. Testing of cement was done as per Indian Standard code IS:12269-1987 and IS:5516 1996 as shown in the below table no:1.

Figue :3.1 cement

Table -1.Physical properties of cement

S.no	Physical Tests	Results obtained	Standard value as per IS 12269-1987
1	Fineness	4%	Not>10%as per IS:4031-part 1
2	Consistency	34%	IS:4031-part 4
3	Initial setting time	48 min	Not lessthan 30 min as per IS:4031-part 5
4	Final setting time	180 min	Lessthan 600 min as per IS:4031-PART 5
5	Specific gravity	3.04	IS:2720 -part 3

3.1.1.Blain's air permeability test

The main aim is to determining the fineness or surface area per gram of the cement as per IS:5516-1996. The fineness of cement is measured as specific surface. Specific surface is expressed as the total surface area in square meters of all the cement particles in one kilogram of cement .The higher the specific surface is, the finer cement will be.

T1=22 sec ;T2=25 sec ;T3=29 sec

$T=\frac{T1+T2+T3}{3}$ =25.33 sec

$S=k\sqrt[3]{T}$ =2632 cm^2/gm

=263.2 m^2/kg

3.2 Fine Aggregates

The Fine Aggregates were used in the present work locally available and has grading of zone-II as per IS:383-1970.The physical properties of fine aggregates are shown in below table no:3.

figure :3.2 Fine aggregates

Table -3. Physical properties of fine aggregates

S.no	Properties	Results
1	Bulk density a)With out compaction b)With compaction	 1403.77 kg/m3 1489.96 kg/m3
2	specific gravity of fine aggregate	2.77
3	Fineness modulus of fine aggregate	2.665
4	Water absorption of fine aggregate	1.2%
5	Type of Zone	Zone II
6	Type of fine aggregate	Medium sand

3.3 Coarse Aggregates

Coarse aggregates were locally available which has maximum size of 20 mm and 12.5 mm .Specific gravity of coarse aggregates as per Is:2386 part -3 and The physical properties are shown in below table no:4.

Figure :3.3 Normal coarse aggregates

Table -4. Physical properties of Coarse aggregates

S.no	Properties	Results
1	Bulk density a)With out compaction b)With compaction	 1279.24 kg/m3 1402.83 kg/m3
2	specific gravity of Coarse aggregate	2.7
3	Fineness modulus of Coarse aggregate	2.883

3.4. Rice Straw Ash and Cotton stalk ash

Boiler burning of rice straw ash and cotton stalk ash at 7000 degree centigrade gives a property called amorphous silica and calcium, which is sticky in nature & packing density of concrete will be more. I have made different experiments on replacing the percentages of cement with rice straw ash and cotton stalk ash . After completion of heating the ashes is placed in room temperature for cooling up to 24 hours' time taken and sieved using sieve analysis particle passed from 90µm sieve,the chemical composition of rice straw ash and cotton stalk ash as shown in table 5(a),the physical properties of both rice straw ash and cotton stalk ash as shown below table no:5(b).

Figure -3.4: Rice straw ash

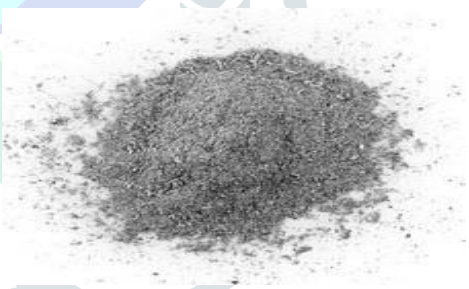


figure -3.5:cotton stalk ash

Table no:5(a) Chemical composition of cement, rice straw ash and cotton stalk ash

Chemical composition	Cement(%)	Rice Straw Ash (%)	Cotton Stalk Ash(%)
SiO_2	21.3	76.8	30
Al2O3	3.8	0.67	-
Fe2O3	2.7	0.64	0.2
CaO	62	4.98	30.8
K_2O	0.7	13.89	37
MgO	3.9	2.65	0.3
Others	5.6	0.24	1.7

Table-5(b). Physical properties of Rice straw ash and Cotton stalk ash

S.no	Properties	Rice straw ash	Cotton stalk ash
1	Specific gravity	2.38	2.79
2	Color	Dark grayish	White gray

3.5 RECYCLED COARSE AGGREGATE

Recycled coarse aggregate (RCA) used in this work. RCA were obtained by crushing old concrete obtained from locally available demolished structures waste. RCA are used with maximum size of 20mm and 12.5 mm. Testing on recycled coarse aggregates is done as per Indian standard. The following tests are conducted the results as shown in below table no:6, treated recycled coarse aggregates properties as shown in Table no:7.

Figure :3.6 Recycled coarse aggregate

Table-6. Test results on Recycled Coarse Aggregate(RCA)

S.NO	Tests on aggregates	Range	Results
1.	Bulk density of coarse aggregate a. Without compaction b. With compaction	 - -	 1486Kg/m³ 1536Kg/m³
2.	Specific gravity	2.6-3.0	2.808
3.	Water absorption	-	1.0%
4.	Crushing test	<45% for base coarse <30% for surface coarse	13.83%

Table -7 Test results on Treated RCA

S.NO	Tests on aggregates	Results
1.	Specific gravity	2.58
2.	Water absorption	1.1%

3.6. Water

The water used in the mix design was tap water is used. So, it was free from suspended solids and organic material, which have affected the properties of fresh and hardened concrete.

Figure :3.7 Water

DETAILS OF SPECIMENS CASTED

Cement is partially replaced with RSA 5% ,CSA10% for all mixtures in concrete and Recycled coarse aggregates were varied in each and every mix are 0%,10%,20%,30%,40%,50%,60% and 70% of the weight of normal coarse aggregates.

4.RESULTS and DISCUSSIONS

Total 7 mortar mixes are prepared with rice straw ash and cotton stalk ashes .out of these mixes one is conventional mixes .three mixes are used with rice straw ash replaced by the weight of cement ratio were 10%,15% and 20% and three mixes are prepared with cotton stalk ash replaced by the weight of cement ratio were 10%,15% and 20%.

All the 7 mix specimens are casted for 28 days and cured as shown in below figure no-9 and compressive test results is shown in table no-8 and graph no:01 and table no:9 and graph no:02.

Table -8 compressive testing results for rice straw ash 7days and 28 days(N/mm^2)

s.no	Rice straw ash	7 days	28 days
01	RSA 0%	34.3	43
02	RSA 5%	34.66	48
03	RSA 10%	36	46
04	RSA 15%	31	39.3

Graph no:01:compressive strength for 7 days 28 days (RSA-mortar)

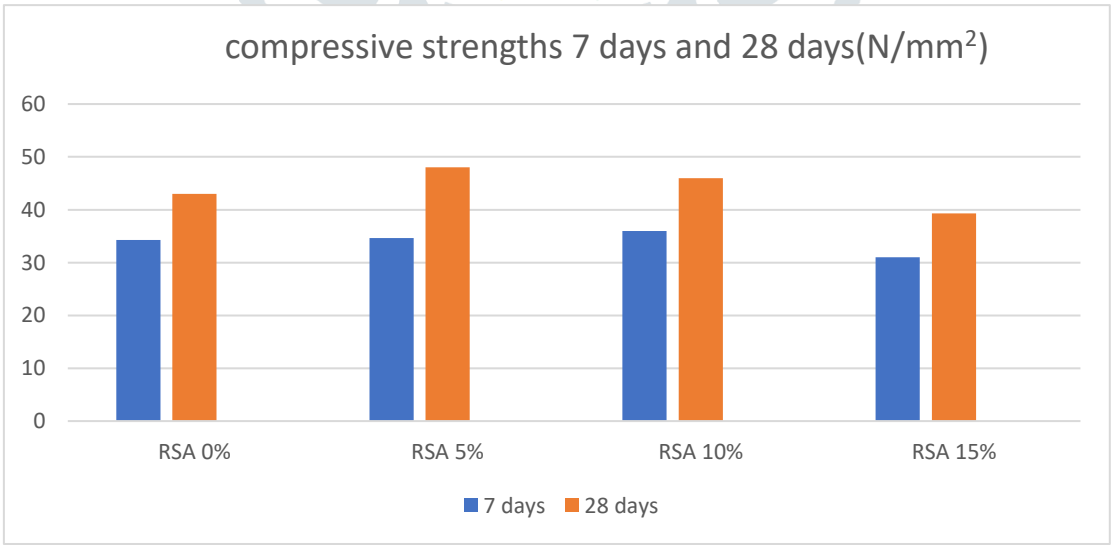
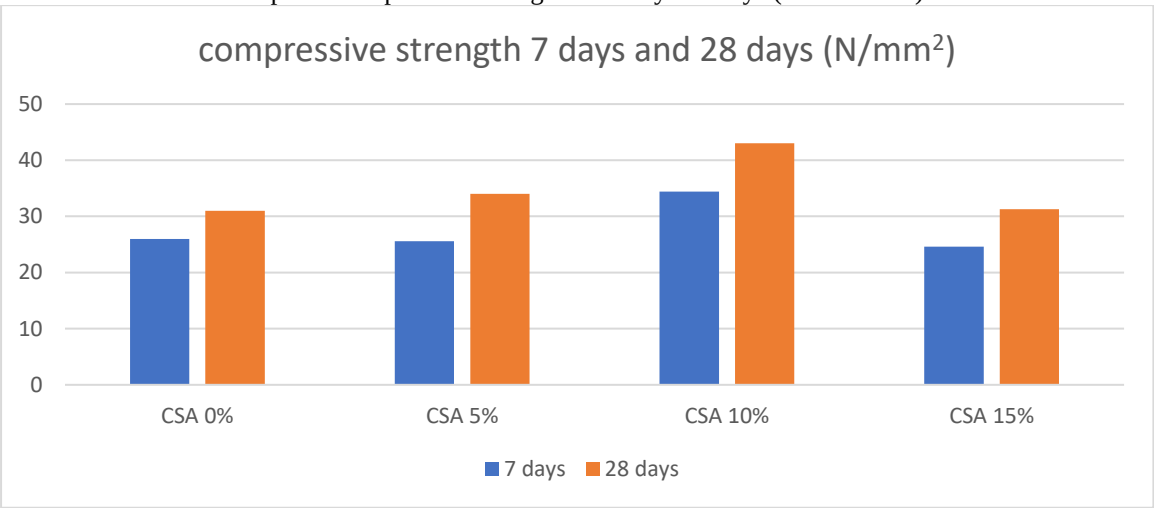


Table -9 compressive testing results for cotton straw ash 7days and 28 days(N/mm^2)

s.no	Cotton straw ash	7 days	28 days
01	CSA 0%	26	31
02	CSA 5%	25.6	34
03	CSA 10%	34.4	43
04	CSA 15%	24.6	31.3

Graph :2: compressive strength for 7 days 28 days (CSA-mortar)



We are prepared 7 controlled mixes varies recycled coarse aggregates and out of these one mix is prepared without RSA,CSA and RCA ,remaining 6 different mixes were prepared with RSA 5% and CSA 10% constantly and varied RCA 10%,20%,30%,40%,50% and 60% respectively and casted all specimen in normal water curing for 7 days and 28 days.

Compressive strength:

Concrete cubes 100×100×100mm are cast. Then the cubes were demould and cured for 28 days. The testing machine consists of two steel bearing platens with hardened faces. The bearing faces of both platens shall be at least as large as, and preferably larger than the nominal size of the specimen to which the load is applied. The load is gradually applied to the specimen until the failure of the specimen occurs.

The testing results as shown in Table no:10 and graph no :03.

The failure load of the specimen is noted.

Compressive strength of concrete calculated using the following formula :

$$\text{Compressive strength} = \frac{Load}{Area} = \frac{p}{A}$$

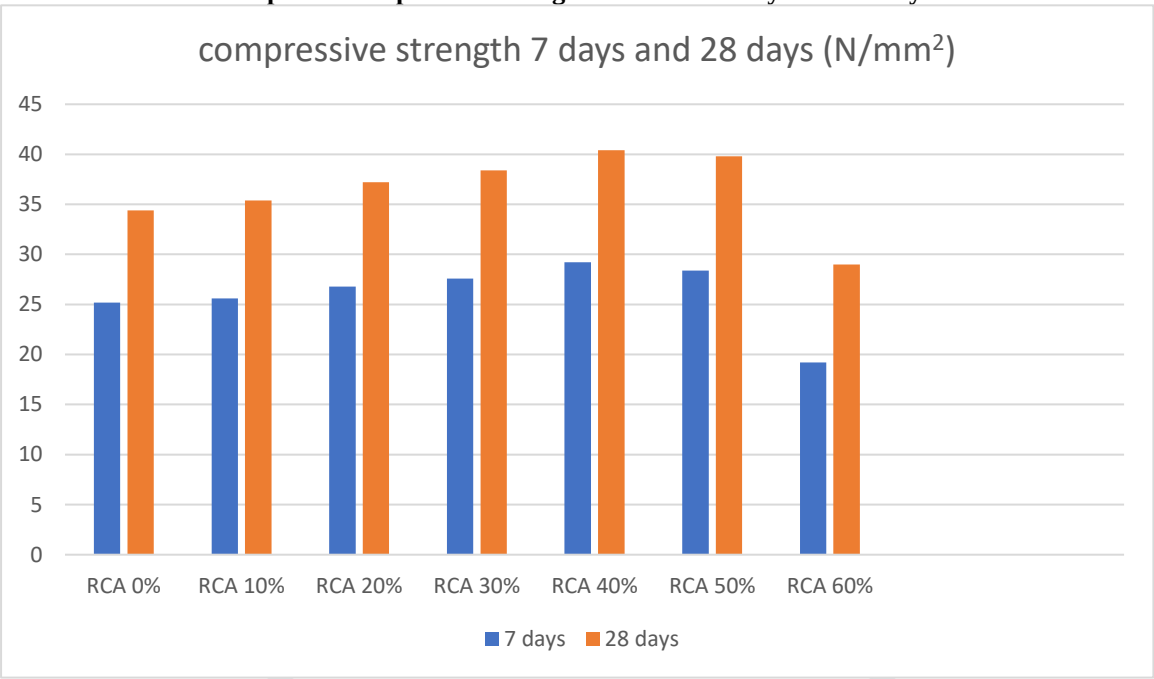
Where A is the area of cube specimen in mm^2

P is the maximum load at failure in N

Table -10 compressive strength results for compressive strength 7days and 28 days(N/mm^2)

s.no	Mixes	7 days	28 days
01	RCA 0%	25.2	34.4
02	RCA 10%	25.6	35.4
03	RCA 20%	26.8	37.2
04	RCA 30%	27.6	38.4
05	RCA 40%	29.2	40.4
06	RCA 50%	28.4	39.8
07	RCA 60%	19.2	29

Graph:03:Compressive strength results for 7 days and 28days



Split tensile strength:

The tensile strength of concrete is determined by preparing standard cylinders 100mm diameter and 200mm height. After curing the cylinders for 28 days, they are tested for split tensile strength in compression testing machine. Cylinder is placed with its longitudinal axis in horizontal direction between plates of compression testing machine. The results as shown in table no:11 and graph no:04.

The load is applied on Split tensile strength (N/mm^2) = $\frac{2P}{\pi LD}$

Where, P is the compressive load on the cylinder in N

L is the length of the cylinder in mm =300 mm

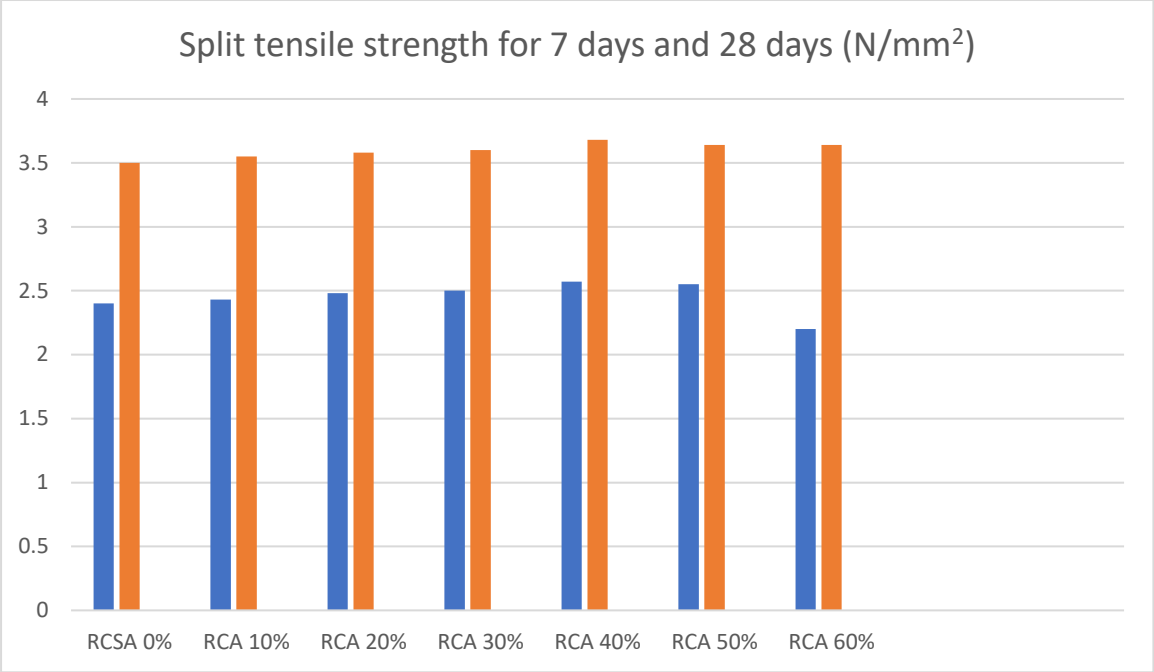
d is diameter of the cylinder in mm = 150mm

cylinder and the load at failure of cylinder is noted.

Table -11 Split tensile strength results for 7 days and 28 days(N/mm^2)

s.no	Mixes	7 days	28 days
01	RCA 0%	2.4	3.5
02	RCA 10%	2.43	3.55
03	RCA 20%	2.48	3.58
04	RCA 30%	2.5	3.6
05	RCA 40%	2.57	3.68
06	RCA 50%	2.55	3.64
07	RCA 60%	2.2	3.13

Graph no:4:Split tensile strength for 7 days and 28 days (Mpa)



Flexural strength:

The flexural strength of concrete is determined by preparing standard beams 100mm x 100mm x 500mm. After curing the cylinders for 28 days, they are tested for flexural strength in universal testing machine. Beam is placed with in horizontal direction between plates of universal testing machine. The load is applied on beam and the load at failure of cylinder is noted. The results as shown in table no:12 and Graph no:06.

Flexural strength (N/mm^2) = $\frac{Pl}{bd*d}$ (when **a** > 13.33cm for 10cm specimen) or

Flexural strength(N/mm^2) $\frac{3Pa}{bd*d}$= (when **a** < 13.33 cm but > 11.0cm for 10.0cm specimen)

Where as b is the width of the specimen. d is the depth of the specimen.

l is the supported length.

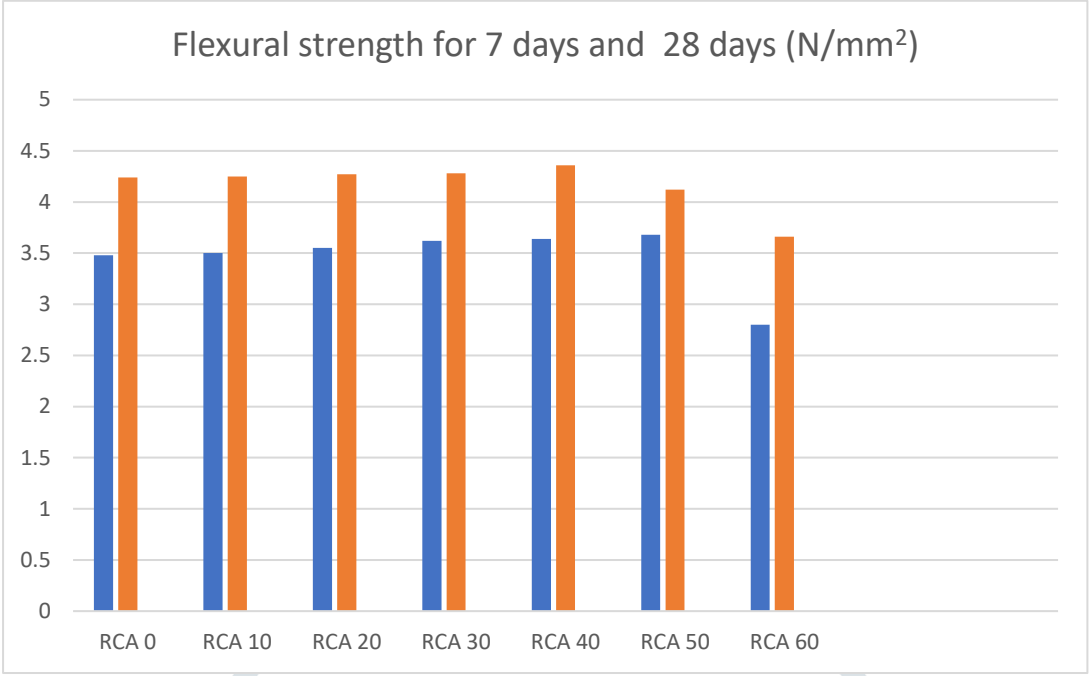
P is the maximum load at the fracture point.

a is the distance between nearest support at the line of fracture

Table -12 Flexural strength results for 7 days and 28 days(N/mm^2)

s.no	Mixes	7 days	28 days
01	RCA 0	3.48	4.24
02	RCA 10	3.5	4.25
03	RCA 20	3.55	4.27
04	RCA 30	3.62	4.28
05	RCA 40	3.64	4.36
06	RCA 50	3.68	4.12
07	RCA 60	2.8	3.66

Graph no:6 :Flexural strength results for 7 days and 28 days



Durability Properties

Durability of concrete means the resistance against deterioration as a prime issue that indicates, whether a concrete is durable or does not possess minimum porosity, loss of cohesiveness and loss of strength. So main purpose of Durability study on concrete is to record the durability performance of the concrete under different environmental conditions. concrete prepared with various material replacement of the cement such as Conventional, RSA 5%, CSA 10% and combined RSA%-CSA 10% and RCA 40% was cured under normal condition as per IS recommendation and were tested at 28 days for determining the Compressive strength.

Acid attack

The acid attack of concrete is the damaging cause of concrete detoriation, an acid solution penetrating the pores of concrete will start to cause some of the constituents will dissolve. Mainly calcium is the first cation to be dissolved it leads to removing the calcium tissues of C-S-H gel its relatively weak in silica gel. So, the strength and weight is automatically occurred huge loss.as shown in table :13

Table:13: Acid attack test values

Mix	Acid attack Saturated dry weight (Kg)		% Weight loss	Compressive strength in MPa	
	Weight before exposure	Weight after exposure		Strength before exposure	Strength after exposure
Conventional	2.418	1.91	21	34.4	20.3
RSA 5%+ CSA 10%+RCA 40%	2.595	2.147	17.26	40.4	22.6

Sulphate attack

The sulphate attack of concrete is the predominant mechanism, sulphate solution penetrating the pores of concrete will start to cause some of the constituents will dissolve. Mainly react with aluminate or calcium hydroxide in cement paste it leads to losses of calcium tissues in C-S-H gel. So, the strength and weight is lightly detoriate as shown in Table 14.

Table :14: Sulphate attack test values

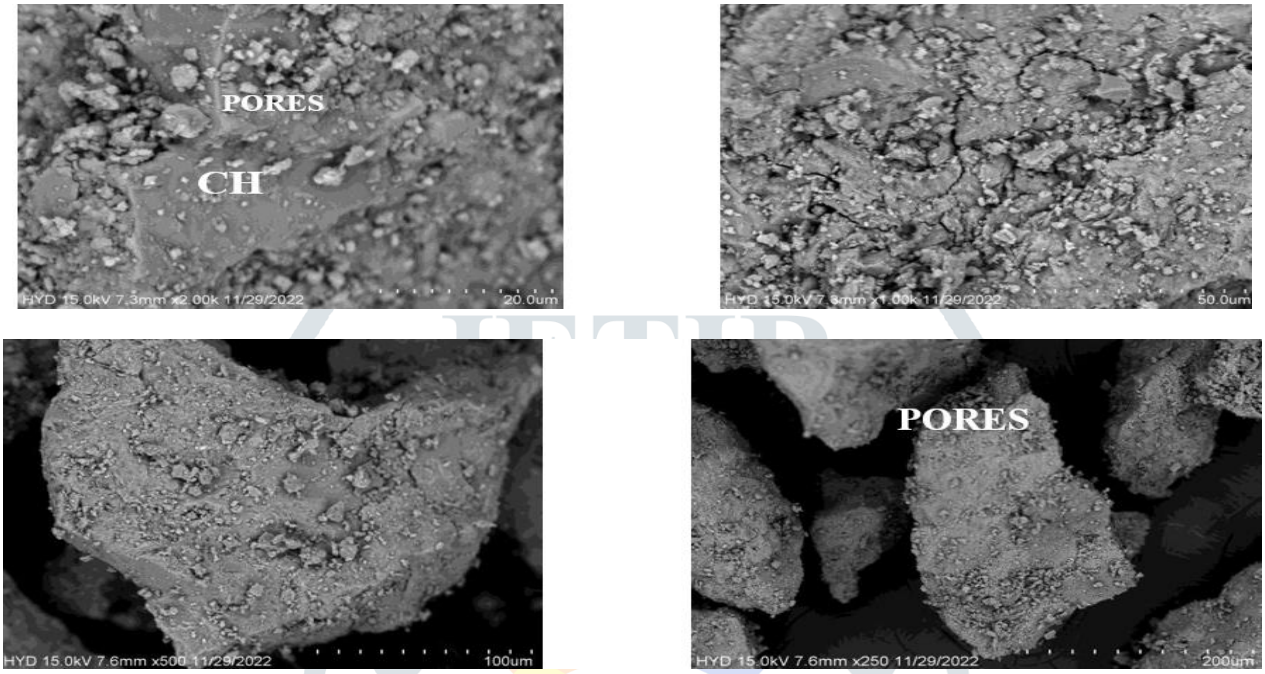
Mix	Sulphate attack Saturated dry weight (Kg)		% Weight loss	Compressive strength in MPa	
	Weight before exposure	Weight after exposure		Strength before exposure	Strength after exposure
Conventional	2.398	2.341	2.37	34.4	29.6
RSA 5%+ CSA 10%+RCA 40%	2.497	2.476	0.86	40.4	31.5

5 Micro Structural Analysis

5.1 Scanning electron microscope

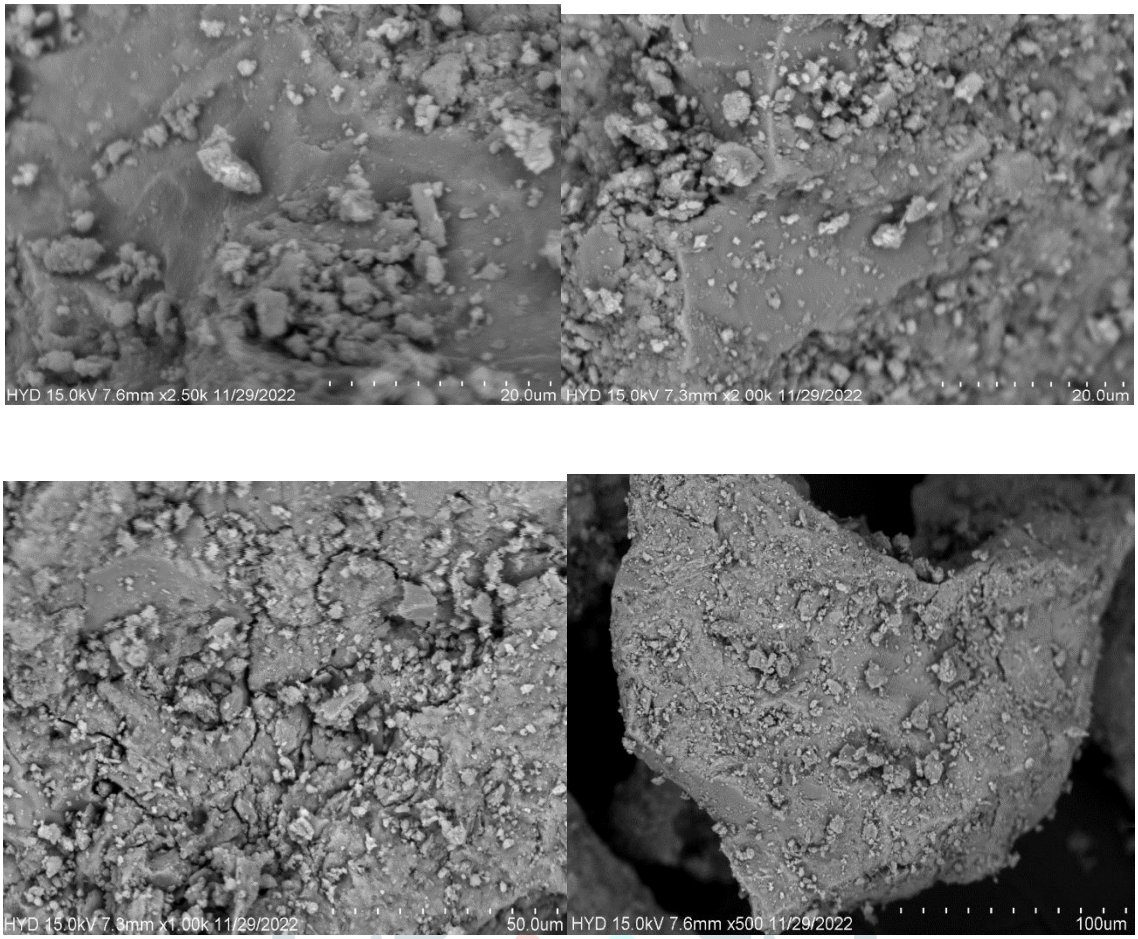
Scanning electron microscope imaging facilitates identification of hardened cement paste constituents with greater contrast, and greater spatial resolution than for optical methods and provides ancillary capability for element analysis and imaging. Figure :5.1 Scanning electron microscopy (SEM) test is carried out on the control mix or conventional mix specimens. In control mix or conventional mix specimen shows cracks and pores are visible with heterogeneously distributed un-hydrated cement clinkers with unreacted portlandite (CH). These unreacted products are responsible for limited strength of concrete.

Figure :5.2 SEM image of conventional concrete, rice straw ash 5% concrete, cotton stalk ash 10% concrete and combined rice straw ash and cotton stalk ash 15% and treated recycled coarse aggregates 50% concrete. The denser microstructure is obtained for the sample containing a higher amount of rice straw ash 5% concrete. The suitable particle size of starting materials is also an important factor for concrete formation and dense micro structure obtaining (which is rich in silica).



Figures:5.1 :Scanning electron microscopy

(SEM)particle image of conventional concrete under 20,50,100,200um



Figures:5.2 :Scanning electron microscopy

(SEM)particle image of Mix (RCA 40%) concrete under 20,50,100,200um

5. Conclusion

The present investigation was intended to find the effective ways to utilize the agriculture waste (RSA,CSA) and construction or demolish waste(RCA) .the following are the finding of this study :

1. The study is revealed that the agriculture waste (rice straw ash and cotton stalk ash) can be incorporated as a coarse aggregate replacement concrete. Though, it gives detrimental effects in compressive properties but the concrete were found to have acceptable strengths and potential development properties specially for a concrete manufacturing .
2. The workability is simultaneously decreased by using CSA and RSA as replacement ration for cement and RCA as replacement ratio of normal coarse aggregates content in contrast with the control mix.
3. The mixes containing 5% RSA,10% CSA and 40% of RCA increased compressive strength in comparison with the control specimen.
4. The optimum percentage of RSA 5%,CSA 10% and RCA to be used in concrete RCA40% based on the results obtained from the experimental study.
5. The durability properties of concrete with different replacement materials compared to the control specimen, such that
Leads to 21% reduction in weight loss.
Leads to 52% reduction in strength
6. This is an eco friendly and economic novel concrete strengthens the waste management practices on the one hand and opens up a new era of water absorbing concrete for hardening the rain water in applications like pavements ,backyard flooring and on the other hand.

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