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Experimental Investigation of Snail Shell Ash (SSA) as Partial Repalacement of Ordinary Portland Cement in Concrete

Syed Talha Zaid[1]
JNTUA College of Engineering, Anantapur
Anantapur, Andhra Pradesh

Dr. Vaishali G. Ghorpade[2]
JNTUA College of Engineering, Anantapur
Anantapur, Andhra Pradesh

***Abstract*— The aim of this study is to assess the suitability of Snail Shell Ash (SSA) as partial replacement for ordinary Portland cement. To carry out the experimental study, Snail Shells were collected from Chennai Beach, made free from any organic and inorganic matter and broken down into pieces and further to fine powder such that powder is capable of passing through a 90µm sieve. This powder is thus called as Snail Shell Ash (SSA), Chemical analysis was performed on this ash to investigate its chemical content. Now to carry out the study, M20 concrete was considered and accordingly ratio was taken for cement, fine aggregate and coarse aggregate respectively according to the mix design done using IS 10262-2009. Tests on fresh concrete were carried out for their workability in terms of Vee – Bee time and Compaction factor. Cubes (150X150X150mm), Cylinders of dimension 150mm diameter and 300mm height were casted. Accordingly a systematic replacement of OPC with 0%, 5%, 10%, 15% and 20% of SSA was carried out. The cubes and cylinders were cured for different days of curing period 7 and 28 days. Finally again tests were carried out on the hardened concrete for different days of curing time and compressive strength for cubes, split tensile test for cylinders were performed. The study gives us conclusion that 5% replacement is optimum with increase of compressive strength by 4.43% for 5% replacement of OPC with SSA for 7 days curing period and increase of compressive strength by 13.59% for 5% replacement and increase of split tensile strength by 3.54% for 5% replacement of OPC with SSA. The workability of concrete is also affected.**

Keywords*—Snail Shell Ash, Ordinary Portland Cement, Concret, Compressive Strength, Split Tensile Strength.

1. INTRODUCTION

Snail Shell is a waste product which is obtained from the consumption of a small greenish-blue marine snail, which rests in a V shaped spiral shell, found in many coastal regions. These shells are a very strong, hard and brittle material. These snails are found in the lagoons and mudflats of the coastal areas, the people in this area consume the edible part as sea food and dispose the shell as a waste product, but a large amount of these shells are still disposed off as waste and with disposal already constituting a problem in areas where they cannot find any use for it, and large deposits have accumulated in many places over the years. It is with this view that this experimental study seeks to investigate into the suitability of Snail Shell Ash as Partial Replacement for Ordinary Portland Cement in Concrete. Also the interest in this experimental study is generated as a result of the fact that snail shell being what it is and with all the properties it possess should be useful for something else, if well processed, especially as a partial replacement of cement, as people have being so curious for some time now about finding an alternative to OPC that would be cheaper, readily available and requiring indigenous technology and equipment. The aim of this study is to assess the suitability of Snail Shell Ash (SSA) as partial replacement for ordinary Portland cement.

II. SCOPE OF INVESTIGATION

The scope of present investigation is to study and evaluate the effect of replacement of Ordinary Portland Cement with Snail Shell Ash (SSA) (0%, 5%, 10%, 15% and 20%) in concrete. Cubes of standard size 150mmx150mmx150mm were casted and tested for 7 days and 28 days compressive strength. Standard cylinders of size 150mm diameter and 300mm height were cast and tested for 28days Split Tensile Strength. To evaluate the strength characteristics in terms of Compressive Strength and Split Tensile Strength a total of 5 mixes were tried with different percentages of Snail Shell Ash (0%, 5%, 10%, 15%, and 20%). In all mixes the same type of aggregate i.e. crushed granite aggregate; river sand and the same proportion of fine aggregate to total aggregate are used. The relative proportions of cement, coarse aggregate, sand and water are obtained by (IS 10262-2009) Code method. M20 is considered as the reference mix. The parameters studies are: Percentage of Snail Shell Ash (SSA) – 0%, 5%, 10%, 15%, and 20% being replaced for Ordinary Portland Cement. For each mix, 6 cubes of size 150 x 150 x 150 mm and 6 cylinders of 150 mm diameter & 300 mm height. Mix design of Concrete with M20 as reference.

III. MATERIALS USED

A. Snail Shell Ash

To carry out the experimental study, the Snail Shells were collected from Chennai Beach, made free from any organic and inorganic matter and broken down into pieces and further to fine powder such that it is capable of passing through a 90µm sieve. This powder is thus called as Snail Shell Ash (SSA), Chemical analysis was performed on this ash to investigate its chemical content.

B. Coarse and Fine Aggregates

The coarse aggregates and fine aggregates used in the investigation are of locally available. The coarse aggregates are of angular shape crushed granite aggregate and are confined to 20 mm size. Fine aggregate used is of river origin and is free from organic matter.

C. Cement

The cement used in this investigation is locally available ACC 53 – Grade Ordinary Portland Cement throughout the investigation.

IV. MATERIAL PROPERTIES

A. Preliminary Tests:

Some preliminary tests were carried on snail shell ash, cement, coarse aggregates and fine aggregates. The Chemical Analysis of Snail Shell ash is as follows.

Constituent	Description	% in OPC	% in Snail Shell Powder
LOI	Loss on Ignition	<3	40.54
SiO_2	Silica	17-25	0.60
Al_2O_3	Alumina	3-8	0.51
Fe_2O_3	Ferrous Oxide	1.5-6	0.56
CaO	Calcuim Oxide	60-67	51.09
MgO	Magnesium Oxide		0.69
SO_3	Sulphur trioxide	1-3	0.19
Na_2O	Sodium oxide	0.2-1.3	1.20
K_2O	Potassium oxide	0.2-1.3	0.12
TiO_2	Titanium dioxide		0.03
P_2O_5	Phosphorus pentoxide		0.21
Mn_2O_3	Manganese oxide		0.02
Cl	Chlorine		0.034

The Chemical analysis was performed in Sree Jayajothi Cements Limited, which is a part of Maha Cements at Sri Nagar, Yanakandla Village, Banaganapalle Mandal, Kurnool District, Andhra Pradesh. The Chemical Analysis was done by adopting X-ray Fluorescence technique in which the snail shell ash is made into a standard tablet from the tablet mould and being compared with the standard tablet samples of cement to get the chemical analysis of the snail shell ash. The chemical Investigation of Snail Shell Ash gives us a conclusion that the SSA has the same properties as that of the OPC nearly satisfying all the requirements. Table 4, shows that the Snail Shell Ash contains the main chemical constituents of cement which are CaO, SiO_2, Al_2O_3 Fe_2O_3,, MgO etc that present in the ordinary Portland cement. The Specific gravity of Snail shell ash is found to be 3.07.

B. Fine aggregates

The specific gravity of fine aggregates used is found to be 2.528. The sieve analysis of fine aggregate is givens in the below table.

Sieve Size In Mm	Wt. Retained In Grams.	Cumulative Wt. Retained In Grams.	% Of Cumulative Wt. Retained.	% Of Cumulative Wt. Passing.	Zone-II
10	-	-	-	100	100
4.75	26	26	2.6	97.4	90-100
2.36	30	56	5.6	94.4	75-100
1.18	170	226	22.6	77.4	55-100
0.6	175	410	41	59.0	30-79
0.3	335	736	73.6	26.4	8-30
0.15	264	1000	100	0	0-10
			244.5		

The soil tested which is considered for the experimental purpose confines to Zone-II.

C. Coarse aggregates

The specific gravity of coarse aggregate is found to be 2.401

D. Cement

The cement considered for the entire investigation is ACC-53 grade cement which is locally available. The properties of cement are as follows.

Sl. No	Property	Test Results
1	Normal Consistency	32%
2	Specific Gravity	3.16
3	Initial Setting Time	75 Minutes
4	Final Setting Time	520 Minutes
5	Soundness (Lechatlier)	2 mm
6	Fineness (Dry Sieve)	98%

V. MANUFACTURE OF CONCRETE

A. Proportions

Here M20 concrete is considered as reference concrete and as per IS Code of design of concrete IS 10262-2009, the proportions considered are

Cement : Fine Agg : Coarse Agg = 1: 1.452 : 2.799.

B. *Quantities of Materials*

The quantities of materials required for each mix are as follows.

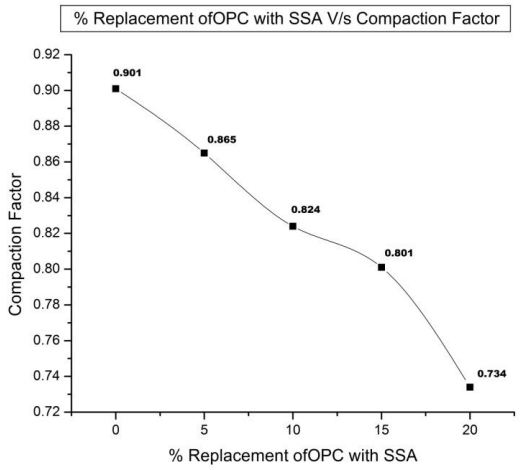
Sl. No	Replacement of OPC with SSA	Quantity of Cement (Kgs)	Quantity of OPC Replaced with SSA (Kgs)
1	0%	27.63	0
2	5%	26.269	1.361
3	10%	24.867	2.763
4	15%	23.541	4.089
5	20%	22.178	5.452

VI. TESTS ON FRESH CONCRETE (RESULTS)

A. *Compaction Factor Test*

The workability is measured in terms of Compaction factor and Vee- bee consistometer test which are going on decreasing with the increase of SSA replacement with OPC. The below table and graph shows us the variation of Compaction factor with % replacement.

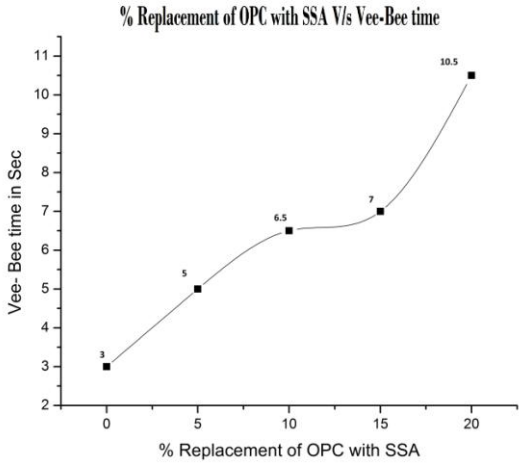
Sl. No	% Replacement Of SSA with OPC	Compaction Factor
1	0	0.901
2	5	0.865
3	10	0.824
4	15	0.801
5	20	0.734



B. *Vee- Bee Consistometer Test*

The Vee Bee time for different % replacement of OPC with SSA is given as follows in the tabular form and in the form of a graph.

Sl. No	% Percentage Replacement Of SSA with OPC	Vee - Bee time
1	0	3
2	5	5
3	10	6.5
4	15	7
5	20	10.5



From the above two workability tests, it indicates that with the increase of % replacement of OPC with SSA, the workability is getting on decreased as of the increment of replacement percentage of OPC with SSA.

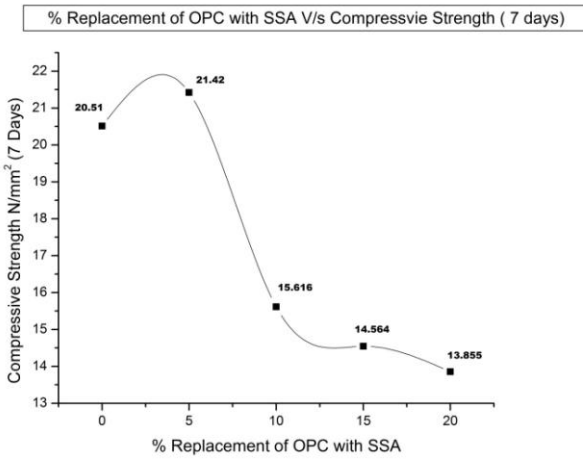
VII. TESTS ON HARDENED CONCRETE (RESULTS)

A. *Compressive Test Results for 7 days*

Compressive Strength for 7 days of curing varies with the increase of percentage replacement of Ordinary Portland Cement with Snail Shell Ash. The tabular form shows the strength of cubes with different percentages of replacement.

Sl. No	% of Snail Shell Ash	Average Failure Load(KN)	Compressive Strength(N/mm^2)
1	0	462	20.51
2	5	483	21.42
3	10	354	15.616
4	15	328	14.546
5	20	312	13.855

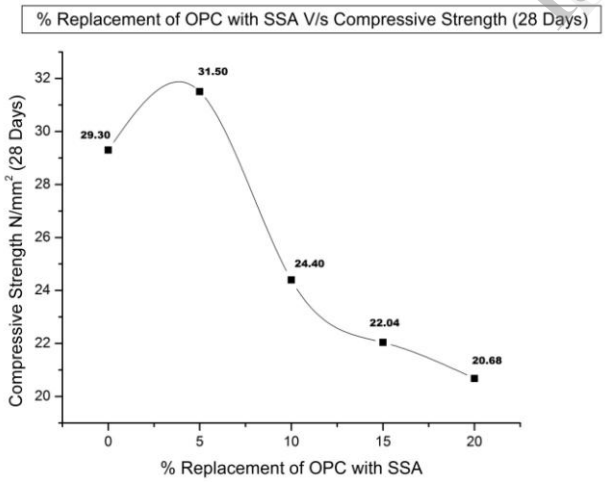
From the above values of compressive strength of concrete cubes casted with different % replacement of OPC with SSA, we can observe that the strength is more for 5% replacement of SSA. At the same time, the strength is getting reduced for 10 % replacement and beyond it. The graphical representation is done in the below figure.



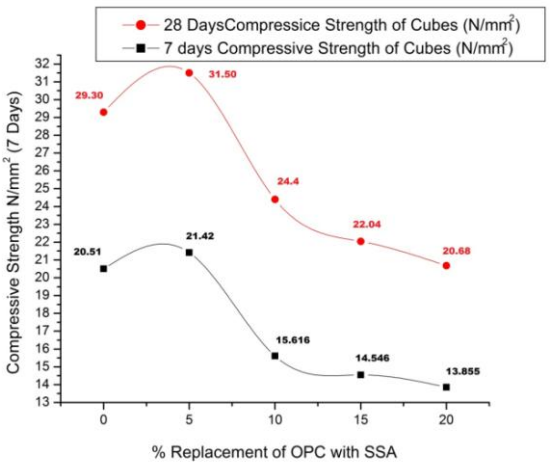
B. Compressive Test Results for 28 days

Even here in the case of 28 days curing period the compressive strength is increased at 5% replacement as shown in the below table as well in the graph.

Sl. No	% of Snail Shell Ash	Average Failure Load(KN)	Compressive Strength (N/mm^2)
1	0	660	27.748
2	5	720	31.52
3	10	550	24.4
4	15	498	22.04
5	20	466	20.68



Keenly observing the compressive test results, the trend is followed as like that of the 7 days compressive strength. Even here in this case of 28 days cubic compressive strength, the strength is increased at 5% replacement than that of the control mix that is at 0% replacement. Beyond 5% of replacement of OPC with SSA, the strength is going on decreasing. The combined results of 7 days as well as 28 days for the compressive strength of concrete cubes is as shown in the below graph.



C. Split Tensile Strength of Cylinders for 28 days

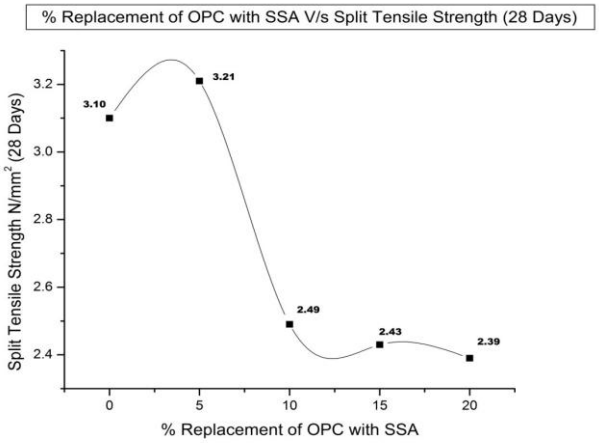
The split tensile strength of concrete for 28 days curing period is as shown in the below table.

Sl. No	% of Snail Shell Ash	Average Failure Load(KN)	Split Tensile Strength(N/mm^2)
1	0	220	3.10
2	5	227	3.21
3	10	172.33	2.49
4	15	176.67	2.43
5	20	170	2.40

Seeing the above tabular form, it is clear that the Split tensile Strength of concrete cylinders for 28 days curing at 5% is more when compared to that of the control mix at 0% replacement. Beyond 5%, the tensile strength is decreasing in some manner even up to 20%. As like that of the Compressive strength of concrete cubes, even here in the case of Split Tensile Strength the trend repeats. At 5% replacement, the split tensile strength is more than that of the control mix. Beyond 5%, the split tensile strength decreases with the increase in the % replacement of Ordinary Portland Cement with Snail Shell Ash. There is an increase in the strength from 0% to 5%. Again in the case of 10%, 15% and 20%, the strength is going on decreasing. So the optimum percentage of replacement is considered as 5% in this case of Compressive Strength of concrete cubes. The Split Tensile Strength of 28 days, the graphical representation can be done as follows.

VIII. CONCLUSION

1. The workability in terms of Vee – bee time factor and compaction factor for the concrete shows that Compaction factor decreases with increasing Snail Shell Ash replacement while the Vee-bee time factor



also decreases with increasing SSA content and the values falls within the value for normal range of concrete.

2. The specific gravity of the SSA obtained is less than that of the OPC that it replaced which means a considerable greater volume of cementitious materials will result from mass replacement.
3. It was observed that the Snail Shell Ash contains all the main chemical constituents of cement in near per percentage of all the constituents compared with that of OPC which means it will serve as a suitable replacement if the right percentage is used.
4. The compressive strength of SSA/OPC concrete Cube specimens shows that the Compressive Strength increases by 4.43% for 5% when compared to the control mix strength for 0% SSA/OPC replacement for 7 days curing period. The Compressive Strength further decreases beyond 5% replacement.
5. The Compressive Strength of SSA/OPC Concrete Cube Specimen show 7.50 % increase in strength for 5% replacement for 28 days over the control mix of 0% OPC/SSA replacement. Further replacement of SSA/OPC beyond 5% results in the loss of strength.
6. Even here in Split tensile Strength, the trend follows as like of the Compressive Strength. For 28 days of curing period, there is an increase of Split Tensile Strength of Concrete Cylinder Specimen by 3.54% over the control mix of 0% SSA/OPC replacement. Beyond 5% replacement, there is a decrease of Split Tensile Strength.
7. In both the cases of Compressive Strength of Concrete Cubes and Split Tensile strength of Concrete Cylinders, we can notice that the Strength increases for 5 % replacement of OPC with SSA. Beyond 5 % replacement, there is decrease in the Strength both for Compressive as well as for Split Tensile Strength. So the present experimental study concludes that **5%** replacement can be considered as optimum Percentage replacement of OPC with SSA.

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