An Experimental Study on Strength Properties of Concrete by Partially Replacing Cement With Snail Shell Ash

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Abstract: The aim of this study is to assess the suitability of Snail Shell Ash as partial replacement for Ordinary Portland Cement. To carry out this experimental study Snail Shells are collected and made free from any Organic & Inorganic matter and heated up to a temperature of 600˚c to 800˚c and further pulverised into fine powder. Such powder is capable of passing through 90µ sieve. This powder is thus called as Snail Shell Ash. Now to carry out the study, M30 grade Concrete was considered and accordingly mix design is done using IS 10262-2009.A systematic replacement of OPC with 10%, 20%, 30%, and 40% of SSA was carried out. The concrete cubes as well as cylinders were casted and are cured for 7 and 28 days, whereas the strength is found and comparision's are made with the conventional concrete.

Keywords: Snail shell, Portland.

I. MATERIALS USED

CEMENT

AGGREGATES

WATER

SNAIL SHELL ASH

Snail Shell Ash is a highly reactive calcium oxide (CaO) used in a range of specialized concrete applications. Snail Shell Ash is produced from the naturally available sea shells, which are collected from nearby sea shore that which is located at Narasapuram, West Godavari district of Andhra Pradesh, India.

Figure 1. Snail Shells

II. MANUFACTURING OF SNAIL SHELL ASH

The production of these Snail Shell Ash involves the following processes:

- Collecting of shells
- Cleaning
- Burning
- Pulverisation

III. PROPERTIES OF SNAIL SHELL ASH (SSA)

Snail Shell Ash is a highly efficient pozzolana and reacts rapidly with the excess calcium hydroxide resulting from OPC hydration, via a pozzolanic reaction, to produce calcium silicate hydrates and calcium aluminium silicate hydrates.

IV. PHYSICAL PROPERTIES OF SSA

SNAIL SHELL ASH PHYSICAL PROPERTIES	
Specific gravity	3.07
Fineness	96%
Colour	Whitish-grey
Physical form	Powder

Table 1. Physical properties of SSA

V. CHEMICAL PROPERTIES OF SSA

Table 2. Chemical properties of SSA

Constituent	**Description**	**% in Snail Shell Powder**
CaO	Calcium Oxide	56.09
LOI	Loss of Ignition	35.54
SiO_2	Silicon Dioxide	0.60
Al_2O_3	Aluminium Oxide	0.51
MgO	Magnesium Oxide	0.69
SO_3	Sulphur trioxide	0.19
Na_2O	Sodium Oxide	1.20
K_2O	Potassium Oxide	0.12
TiO_2	Titanium Dioxide	0.03
Cl	Chlorine	0.034
Fe_2O_3	Ferrous Oxide	0.56
P_2O_5	Phosphorous pentoxide	0.21
Mn_2O_3	Manganese oxide	0.02

VI. ADVANTAGES

Concrete with Snail Shell Ash offers many advantages. Some of them are as follows:

- Facilitate finishing concrete surfaces by rubbing and smoothing due to the lack of stickiness of concrete to the tool and good thixotropic.
- It reduces the amount of cement in the formation of concrete, especially in concrete with high requirements for water resistance.
- Can significantly increase the residual strength of refractory concrete after firing; typically lose 30% of its strength after heating to 600^0C.
- The strength and durability of concrete increases.
- Use of SSA accelerates the initial set time of concrete.
- The cross sectional areas of structural members can be reduced safely, so saving in concrete and can be economically used for high rise buildings, dams, bridges etc.
- It imparts improved water-tightness, so safely used for water retaining structure, off shore structure etc.
- Confers high early strength, allows a quicker reuse of formwork, and thus enhances the production rate.
- Eco-friendly.

- SSA increases resistance to chemical attack and prevention of Alkali Silica Reaction.
- SSA reduces autogenously shrinkage in concrete.
- SSA disperses more easily in the mixer with less dusting.
- SSA offers high abrasion resistance concrete so used for industrial flooring, Warehouses, Container Depots, Roads etc.
- SSA reduces heat of hydration leading to better shrinkage and crack control.
- Better Spray ability.
- Lesser Rebound so used in shotcrete with reduced wastage.
- Durability.
- Change in pore size and structure results in decreasing of permeability.
- Reduction in available alkalis to cause Alkali Silica Reaction.
- Strength.
- Results in stronger concrete.

VII. APPLICATIONS

High Strength Concrete with Snail Shell Ash as admixtures offers many advantages as mentioned above. So it can be used for

Dams, Bridges, Water retaining structures, High rise buildings, off shore structures, Industrial flooring, Warehouses, Container Depots, Roads, Lining
Mass concreting, Aqueducts, Nuclear power stations, Shotcrete (Reducing cracking) ,Oil and gas well lining, High performance and high strength concrete ,Lightweight concrete, Structural members where cross section required being small.

Mix design for "M30" Grade

(a) Stipulations for proportioning:

1) Grade designation	M30
2) Type of cement	OPC53 grade conforming to IS 12269
3) Type of mineral admixture	Snail Shell Ash
4) Maximum nominal size of aggregate	20mm
5) Minimum cement content	300 kg/m3
6) Maximum water-cement ratio	0.50
7) Workability	75 mm (slump)
8) Exposure condition	Moderate (for reinforced Concrete)
9) Method of concrete placing	Hand placing
10) Degree of supervision	Good
11) Type of aggregate	Sub- angular aggregate
12) Maximum cement (OPC) content	450kg/m3

(b) Test data for materials:

	Cement used	Nagarjuna OPC 53 grade
1)	Specific gravity of cement	3.10
2)	Specific gravity of coarse aggregate	2.85
3)	Specific gravity of fine aggregate	2.69
4)	Specific gravity of Snail Shell Ash	3.07
5)	Water absorption coarse aggregate fine aggregate	NIL NIL
6)	Free (surface) moisture Coarse aggregate Fine aggregate	NIL NIL

7) Sieve analysis

Coarse aggregate	Nominal max. size of aggregate 20mm as per IS-383
Fine aggregate	Conforming to grading zone-III of table-4 of IS-383

(C) Target Strength For Mix Proportioning

$Fc_k = f_{ck} + 1.65S$

Where

Fc_k = target average compressive strength at 28 days,

f_{ck} = characteristic compressive strength at 28 days, and

s = standard deviation.

From Table 1of IS 456 Standard Deviation, S = 5 N/mm2.

Therefore, target strength = 30+1.65 x 5 = 38.25N/mm2

(D) Selection Of Water-Cement Ratio

From Table 5 of IS 456, maximum water-cement ratio =0.50.

Based on experience, adopt water-cement ratio as 0.45.

Hence O.K.

(E) Selection Of Water Content

From Table2 of IS 456 maximum water content

For 20 mm aggregate =186 litre (for 25 to 50 mm slump range)

Estimated water content for sub angular aggregate (reducing 10 Ltr water)

=176 litre

Estimated water content for 75 mm slump

= 176+ (3/100) x176

= 181.28 litre

(f) Calculation Of Cement:

Water-cement ratio = 0.45

Cement content = 181.28/0.45 =402.85 kg/m^3

From Table 5 of IS-456, minimum cement content for "moderate" exposure condition = 300kg/m^3

402.85 kg/m^3 > 300 kg/m^3

Hence, O.K

(g) Proportion Of Volume Of Coarse Aggregate And Fine Aggregate Content:

From Table 3 of IS 456 volume of coarse aggregate corresponding to 20mm size aggregate and fine aggregate (Zone III)

For water-cement ratio of 0.45 = 0.65.

Volume of fine aggregate content = 1 - 0.65 = 0.35

(h) Mix Calculations:

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = 1m^3

b) Volume of cement = $\frac{\text{mass of cement}}{\text{sp.gr. cement}} \times \frac{1}{1000}$

= $\frac{402.85}{3.10} \times \frac{1}{1000} = 0.13 m^3$

c) Volume of water = $\frac{mass\ of\ water}{sp.gr.water} \times \frac{1}{1000}$

= $\frac{181.28}{1} \times \frac{1}{1000} = 0.182 m^3$

d) Volume of Total aggregate = a-(b+c)

= 1- (0.13+0.182) = $0.688 m^3$

e) Mass of coarse aggregate = d X volume of C.A X sp.gr.C.A X 1000

= 0.688 X 0.65 X 2.85 X 1000

= 1274.52 kg

f) Mass of fine aggregate = d X volume of F.A X sp.gr.F.A X 1000

= 0.688 X 0.35 X 2.69 X 1000

= 647.76 kg

Material required for M30 grade concrete per cubic meter quantity of concrete:-

Material	Water		Cement		Fine aggregate		Coarse aggregate
Kgs /cum	181.28		402.85		647.76		1274.52
Ratio	0.45	:	1	:	1.61	:	3.17

Mix proportions of M30 grade: 1: 1.61: 3.17

Water cement ratio = 0.45

Specific gravity of cement s_c = 3.10

Specific gravity of fine aggregate = 2.69

Specific gravity of coarse aggregate = 2.85

V = volume of each cube = $0.15 \times 0.15 \times 0.15 = 3.375 \times 10^{-3}\ m^3$

Volume of cement = 1.360kg

Volume of fine aggregate = 2.186kg

Volume of coarse aggregate = 4.301kg

Volume of water = 0.615 lit

Volume of each cylinder = $\left(\frac{\pi}{4}\right) \times 0.15^2 \times 0.30 = 5.30 \times 10^{-3}\ m^3$

Volume of cement = 2.137kg

Volume of fine aggregate = 3.436kg

Volume of coarse aggregate = 6.760kg

Volume of water = 0.965 lit

VIII. RESULTS AND DISCUSSIONS

Compressive Strength Values For Replacement Of Cement By Snail Shell Ash

Cubes:

Table 3. 7-Days Compressive Strength Results

S.No	Cement Replacement with Snail shell ash by (%Mix)	Compressive Strength(MPa)
1	0	23.42
2	10	25.02
3	20	26.53
4	30	26.08
5	40	24.62

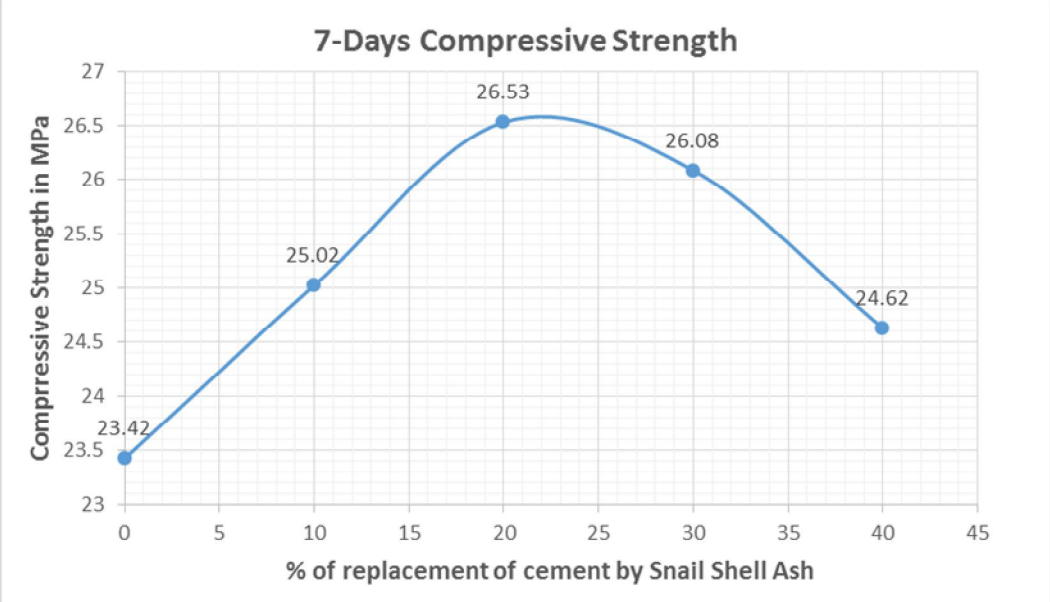

Figure 2. 7Days Compressive Strength

Table 4. 28-Days Compressive Strength Results

S.No	Cement Replacement with Snail Shell Ash by (%Mix)	Compressive Strength(MPa)

1	0	37.2
2	10	38.97
3	20	40.17
4	30	39.28
5	40	38.08

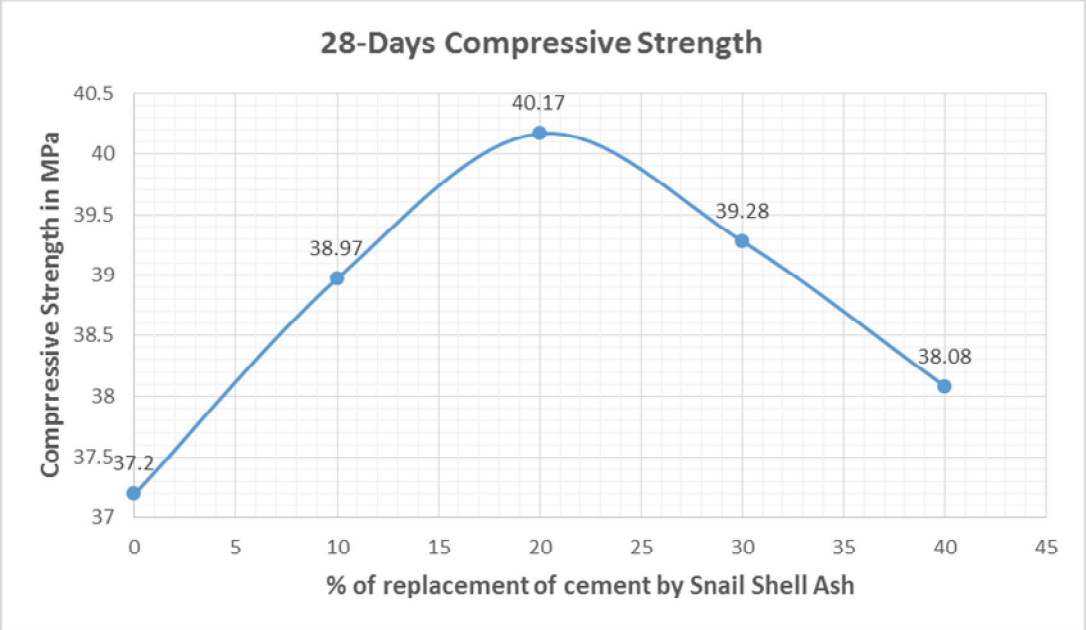

Figure 3. 28 Days Compressive strength

Table 5. Comparision of Compressive Strength Results for Replacement of Cement by snail shell ash

S.No	Cement Replacement with Snail Shell Ash by (%Mix)	7 Days	28 Days
1	0	23.42	37.2
2	10	25.02	38.97
3	20	26.53	40.17
4	30	26.08	39.28
5	40	24.62	38.08

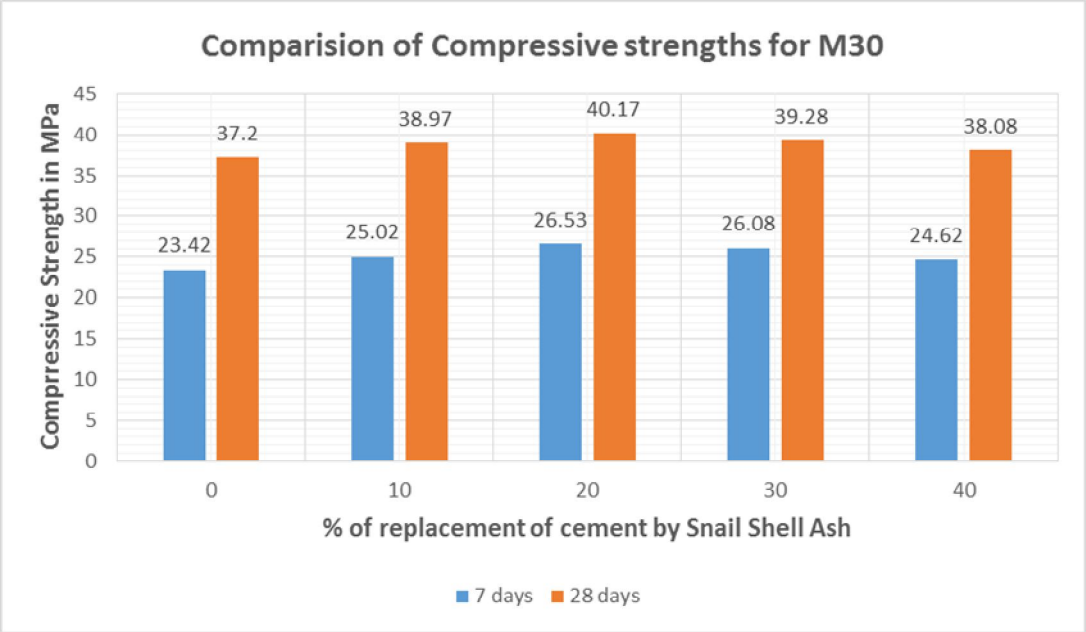

Figure 4. Comparision of Compressive strengths for M30

IX. SPLIT TENSILE STRENGTH VALUES FOR REPLACEMENT OF CEMENT BY SNAIL SHELL ASH

Cylinders:

Table 6. 7-Days Split Tensile Strength Results

S.No	Cement Replacement with Snail Shell Ash by (%Mix)	Split Tensile Strength(MPa)
1	0	1.692
2	10	1.904
3	20	2.186
4	30	1.974
5	40	1.763

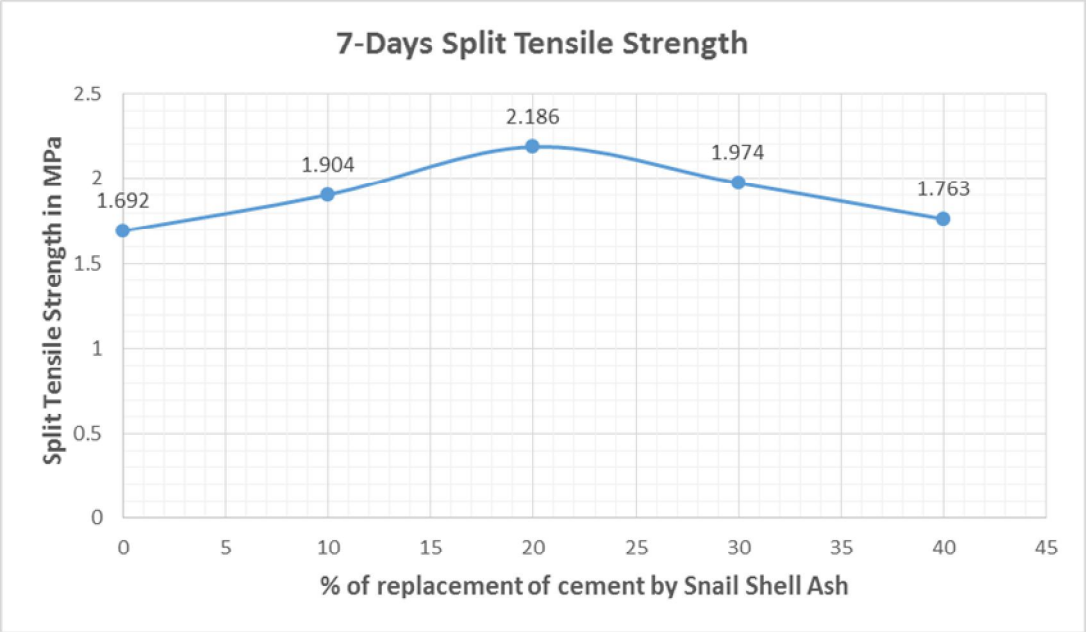

Figure 5. 7 Days Split Tensile strength

Table 7. 28-Days Split Tensile Strength Results

S.No	Cement Replacement with Snail Shell Ash by (%Mix)	Split Tensile Strength(MPa)
1	0	2.82
2	10	3.032
3	20	3.596
4	30	3.384
5	40	3.243

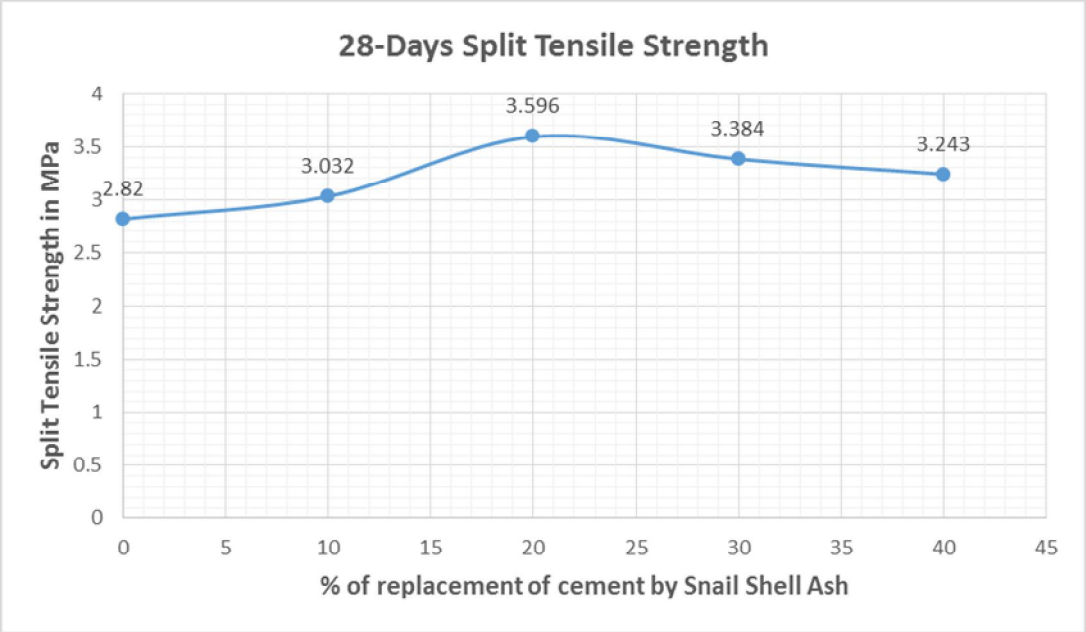

Figure 6. 28 Days Split Tensile strength

Table 8. Comparision of Split Tensile Strength Results for Replacement of Cement by Snail Shell Ash

S.No	Cement Replacement with Snail Shell Ash by (%Mix)	7 Days	28 Days
1	0	1.692	2.82
2	10	1.904	3.032
3	20	2.186	3.596
4	30	1.974	3.384
5	40	1.763	3.243

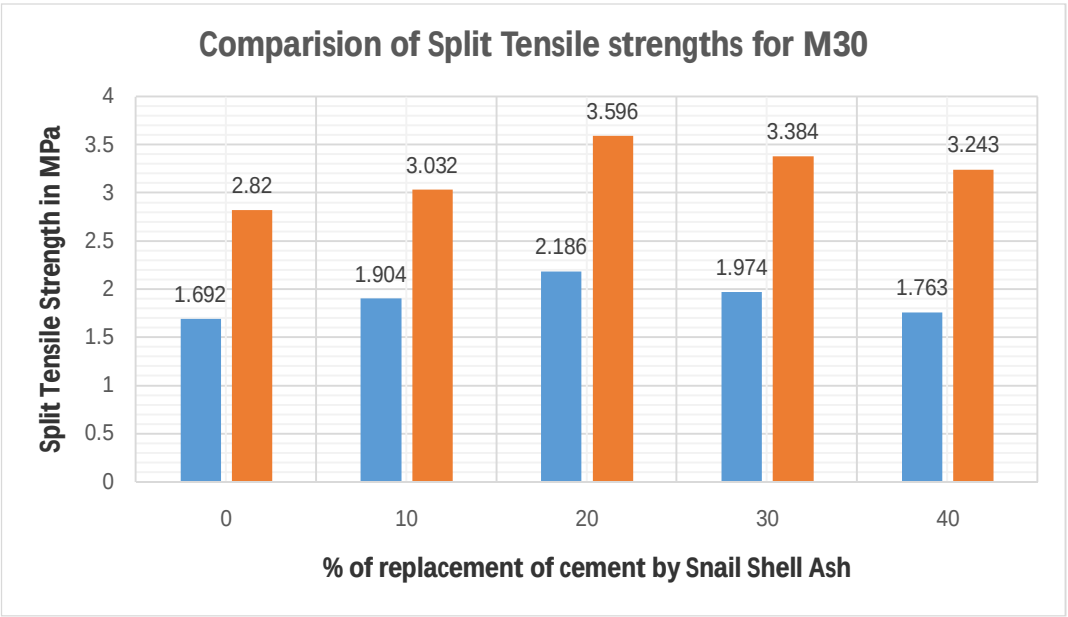

Figure 7. Comparision of Split Tensile strengths for M30

X. CONCLUSIONS

1) From the above study we conclude that the compressive and split tensile strength of the concrete cubes and cylinders has gradually increased up to addition of 20% of Snail Shell Ash.
2) Compared to compressive and split tensile strengths of 10%, 20% replacement of cement by Snail Shell Ash, the compressive and split tensile strengths of 30% & 40% Snail Shell Ash concrete has been decreased.
3) Whereas comparing to traditional concrete, compressive and split tensile strengths of concrete has been increased by replacing 20% of cement by Snail Shell Ash.
4) The gain in compressive strength is improved depending upon the replacement level of OPC by Snail Shell Ash.
5) The Snail Shell Ash inclusion generally improves tensile strength, flexural strength, bond strength and modulus of elasticity. The quantum of increase in the individual properties depends upon replacement level.
6) The Snail Shell Ash in concrete can allow major carbon dioxide reductions and also increase the service life of concrete structure.

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