EXPERIMENTAL INVESTIGATION OF INCORPORATION OF SEASHELL CONCRETE

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Abstract:
Impact resistance, being the ability of a material to resist impact loads without undergoing plastic deforming or failing is one of the fundamental characteristics of concrete. However, failures of bridges, tunnels and dams are increasing now-a-days. Their failures are directly connected to impact loads; violent wind loads in bridges, seismic loads on tunnels and turbulent wave surges in dams. This project attempts to improve impact resistance/strength of concrete by replacing fine aggregate with a suitable replacement material. Cockle seashell species was found to be ideal as it had high calcium content while being relatively stronger than other seashells. Of the different methods tried to grind the Cockle shells into fine aggregate sizes, it was found that machine mill grinding was most efficient. Blended cement with 27% fly-ash was used, to avoid excessive heat of hydration during curing. Four different replacement percentages (by volume) were evaluated; 4%, 8%, 12% and 16%. Numerous specimens were cast and a variety of destructive and Non-Destructive Tests (NDT) were performed. NDTs namely, rebound hammer test and ultrasonic pulse velocity test were conducted on slab specimens that were subjected to mild impact loading. Relatively higher magnitude impact loads were used for destructive weight drop impact testing. The mix with 4% fine aggregate replacement showed increased compressive, tensile and flexural strengths when compared to specimens of the other mixes as well as the control mix. The 4% fine aggregate replaced mix also displayed significantly higher impact resistance during the weight drop test. Furthermore, it maintained greater surface hardness and lesser density of internal cracks during non-destructive testing.

Keywords: *Impact resistance; Cockle seashell; seashell concrete; NDT*

1. INTRODUCTION:

History presents that before concrete or cement became popular for construction, stone and lime were used. Prior to that, earth, mud, clay, dried brick, straw and timber were the popular construction materials. As we look deep into the trends and paths followed in the past, it can be observed that humans were constantly focused on identifying and incorporating different materials in the field of construction.

These developments are done in order to improve several aspects of the field such as strength, durability, wear and tear resistance, freeze and thaw resistance, longevity and of course, cost. Furthermore, advancement of infrastructure, which directly results in the enhancement of living condition and lifestyles of society, necessitates such improvements in construction methods and materials. A pivotal point in history, in this context, is the invention of Portland cement in 1824.

Once cement and concrete were invented, complete replacement of construction materials did not take place, as concrete's characteristics were, to a great degree, ideal for construction. However, the components that constituted concrete namely cement, sand and coarse aggregate, have been constantly subjected to improvement. This perfection is and has always been done in two ways; replacement and addition. Our project is centered around improvement of concrete characteristics by replacement.

1.1. DIFFERENT MATERIALS THAT ARE REPLACED:

Cement - Fly ash, ground granulated blast furnace slag (GGBFS), silica fume, limestone fines, ceramic waste, timber ash and ground natural zeolites.

Fine aggregate - Rice husk, manufactured sand, slag sand, powdered glass, fly ash, quarry dust, processed crushed rock fines, Mersey silt, sugarcane bagasse ash, groundnut shell, cork, tobacco waste, crushed over-burnt brick and tile.

Coarse aggregate - Expanded polystyrene, crushed rubber, glass, high- density polythene, paper pulp, destroyed bitumen road, wooden pieces, plastic and broken concrete debris.

1.2. REPLACEMENT OF FINE AGGREGATE:

In our project, we perform partial replacement of fine aggregate with seashell powder of a particular species. Our aim is to improve the impact strength of concrete. Usually, the degree of replacement is measured by percentage of material replaced by volume. The percentage of replacement varies depending on nature and type of the substitute and resulting strength. Our project employs replacement of fine aggregate in four different percentages; 4%, 8%, 12% and 16%. Of the 200,000 species of mollusks, the species of relatively higher calcium content is Cockle. Therefore, it was chosen as the appropriate specimen for this project.

2.TEST OF MATERIALS:

Cement, fine aggregate (sand), coarse aggregate (crushed stone) and seashell powder are tested and their essential properties are determined. A list of tests has been performed for all different materials they are listed below**:**

2.1. TESTS ON CEMENT

2.1.1. SPECIFIC GRAVITY:

The specific gravity of OPC was obtained as 3.05 and the specific gravity of PPC was obtained as 2.75.

Cement	W1 (g)	W2 (g)	W3 (g)	W4 (g)	Concordant value of specific gravity
OPC	32	69	94	72	3.05
PPC	32	54	84	72	2.75

2.1.2. FINENESS TEST:

Percentage weight of residue of both OPC and PPC was obtained as 4%, which is lesser than 10%. Therefore, both the cements are acceptable for use.

2.1.3. SOUNDNESS TEST:

Soundness of PPC = 9mm and soundness of OPC = 7mm (As per guidelines for OPC (IS 12269:1987) and for PPC (IS 1489:1991 Part 1), soundness must be lesser than 10mm). Therefore, the cements are acceptable.

2.1.4. COMPRESSIVE STRENGTH AT 28 DAYS:

Compressive strength of OPC at 28 days was obtained as 53.5Mpa and the compressive strength of PPC at 28 days was obtained as 55Mpa. Since Grade 53 cement is used, the above results are acceptable (IS 4032:1988 part 6).

2.2. TESTS ON SAND:

2.2.1. SIEVE ANALYSIS:

Two kilograms of sand are taken and sieved in sieves of sizes ranging from 4.75mm to 0.075mm. The results are given in Table 5.3.

S. No	Size of sieve (mm)	Weight of sand retained (g)	% Weight retained	Cumulative percentage weight	Percentage finer
1	4.75	0	0	0	100
2	2.36	24	1.2	1.2	98.8
3	1.4	156	7.8	9	91
4	0.6	310	15.5	24.5	75.5
5	0.3	1086	54.3	78.8	21.2
6	0.15	358	17.9	96.7	3.3
7	0.075	56	2.8	99.5	0.5
8	Pan	10	0.5	100	0

2.2.2. SPECIFIC GRAVITY TEST:

The specific gravity of sand was obtained as 2.5.

Three trials were performed and the concordant value is presented in the table below.

W1 (g)	W2 (g)	W3 (g)	W4 (g)	Concordant value
613	1059	1760	1493	2.5

2.3. TESTS ON CRUSHED STONES:

2.3.1. SPECIFIC GRAVITY TEST:

The specific gravity of crushed stone was obtained as 2.823.

W1 (g)	W2 (g)	W3 (g)	W4 (g)	Concordant value
658	1104	1848	1560	2.823

2.3.2. WATER ABSORPTION TEST:

Water absorption of Coarse aggregate was obtained as 0.4%.

Weight of oven dried specimen (W1) (g)	Weight of saturated specimen (W2) (g)	Weight of water absorbed (W3) (g)	% Of water absorption (W3/W1*100)
1000	1004	4	0.4

2.4. TEST ON SHELL POWDER:

2.4.1. SPECIFIC GRAVITY TEST:

Unlike cement, seashell powder does not respond inertly to kerosene or diesel. There is partial hardening irrespective of the medium used, except when a particular cleaning fluid is used. This cleaning fluid is used to cleanse and purify the seashells in industries. As we were unable to get a hold of that particular fluid, we researched a study that did.

In that particular study, the specific gravity of Cockle seashell powder was 2.5. Necessary modifications in water content were made while mix design was carried out.

2.4.2. WATER ABSORPTION TEST:

Seashell powder reacts with kerosene and diesel and gradually hardens, and thus, tests like specific gravity and water absorption cannot be performed on it. 1 Litre of water was needed more than usual due to the absorbing nature of seashell powder. The average value of water absorption is 8.14%.

Weight of dish with seashell powder (g)	Weight of dish with seashell powder and water (g)	Weight of dish after heating and drying (g)	Water absorption (%)
110	118.8	8.8	8%
110	119.13	9.13	8.3%
110	118.91	8.91	8.1%

2.4.3. SIEVE ANALYSIS:

One kilogram of seashell powder was taken and sieved in meshes with sizes ranging from 4.75mm to 0.075mm.

S. No	Size of sieve (mm)	Weight of seashell powder retained (gm)	% Weight retained	Cumulative percentage weight	Percentage finer
1	4.75	0	0	0	100
2	2.36	0	0	0	100
3	1.4	0	0	0	100
4	0.6	2	0.2	0.2	99.8
5	0.3	932	93.2	93.4	6.6
6	0.15	47	4.7	98.1	1.9
7	0.075	18	1.8	99.9	0.1
8	Pan	1	0.1	100	0

2.5. DESTRUCTIVE TESTS:

2.5.1. COMPRESSIVE STRENGTH TEST:

The compressive strength tests are performed on 7th, 14th and 28th days. The results of those tests are shown in the following tables.

7th DAY COMPRESSIVE SRENGTH TEST RESULTS

Mix	Strength of 1st specimen (N/mm^2)	Strength of 2nd specimen (N/mm^2)	Strength of 3rd specimen (N/mm^2)	Average strength (N/mm^2)
Control	14.49	15.1	15.20	14.93
PPC 4%	18.36	20.01	19.30	19.22
PPC 8%	14.76	15.24	14.50	14.83
PPC 12%	13.49	13.05	13.40	13.31
PPC 16%	12.67	12.22	12.10	12.33

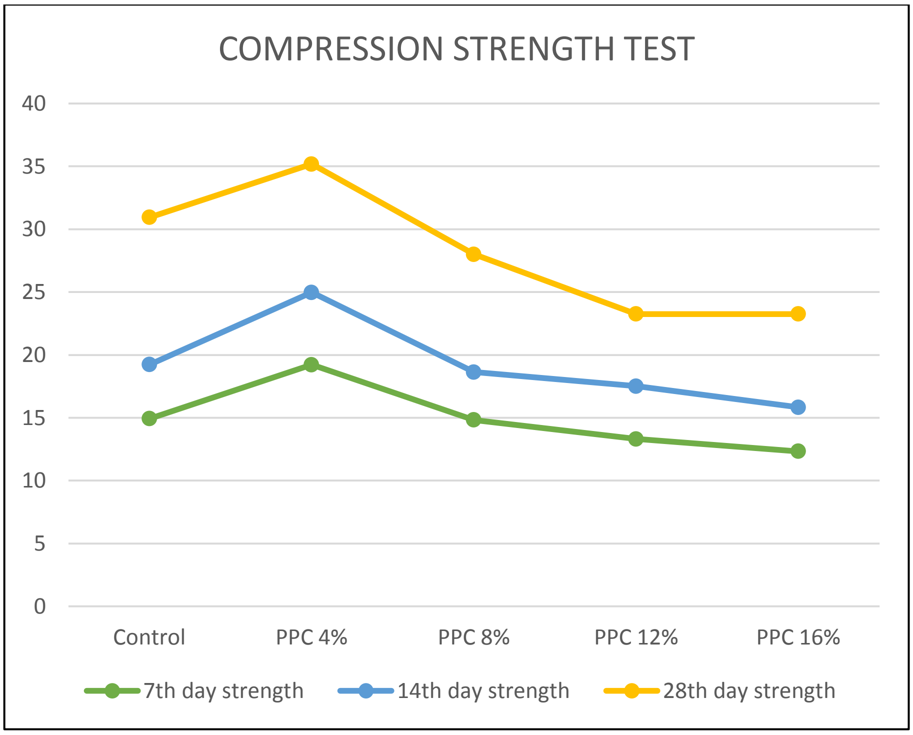
14th DAY COMPRESSIVE SRENGTH TEST RESULTS

Mix	Strength of 1st specimen (N/mm^2)	Strength of 2nd specimen (N/mm^2)	Strength of 3rd specimen (N/mm^2)	Average strength (N/mm^2)
Control	19.20	19.50	19.00	19.23
PPC 4%	24.84	26.00	24.10	24.98

PPC 8%	18.71	18.60	18.62	18.64
PPC 12%	17.64	17.03	17.90	17.52
PPC 16%	16.82	14.50	16.20	15.84

28th DAY COMPRESSIVE SRENGTH TEST RESULTS

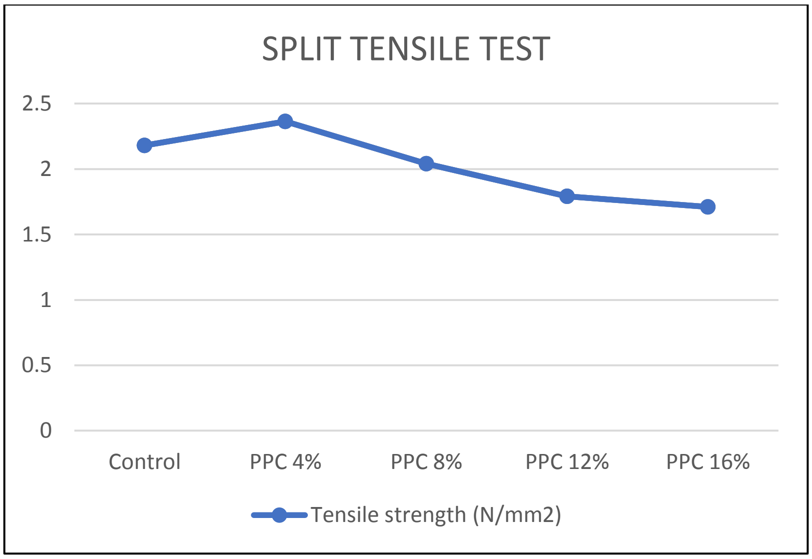
Mix	Strength of 1st specimen (N/mm^2)	Strength of 2nd specimen (N/mm^2)	Strength of 3rd specimen (N/mm^2)	Average strength (N/mm^2)
Control	30.55	31.2	31.11	30.95
PPC 4%	35.67	34.11	35.78	35.19
PPC 8%	29.78	25.78	28.44	28
PPC 12%	24.44	22.22	25.1	23.92
PPC 16%	24.5	22.9	22.36	23.25



2.5.2. SPLIT TENSILE TEST:

The results for the split tensile test are shown in below Table.

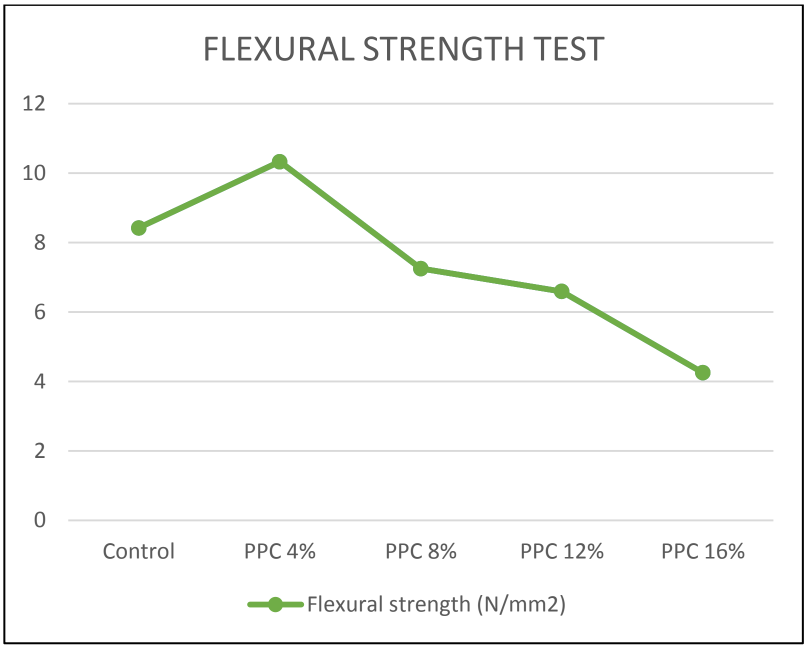
Mix	Load from compression testing machine (kN)			Tensile strength (N/mm^2)
	Specimen 1	Specimen 2	Specimen 3	
Control	152	156	154	2.179
PPC 4%	167	164	170	2.363
PPC 8%	143	143	144	2.04
PPC 12%	128	130	131	1.79
PPC 16%	120	119	119	1.71



2.5.3. FLEXURAL STRENGTH TEST:

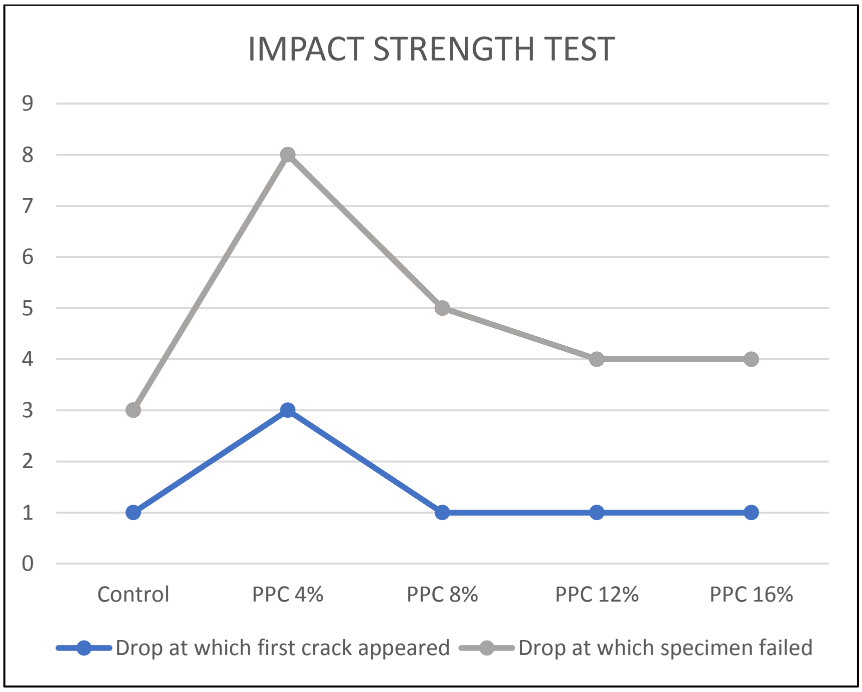
Mix	Load from two-point flexure testing machine (kN)			Flexural strength (N/mm^2)
	Specimen 1	Specimen 2	Specimen 3	
Control	17	17	16.5	8.42
PPC 4%	21	20	21	10.33
PPC 8%	14	15	14.5	7.25

PPC 12%	12	13.5	14	6.59
PPC 16%	8	9	8.5	4.25



2.5.4. IMPACT STRENGTH TEST/WEIGHT DROP TEST:

Mix	Drop at which first crack appeared	Drop at which specimen Failed
Control	1	2
PPC 4%	3	5
PPC 8%	1	4
PPC 12%	1	3
PPC 16%	1	3

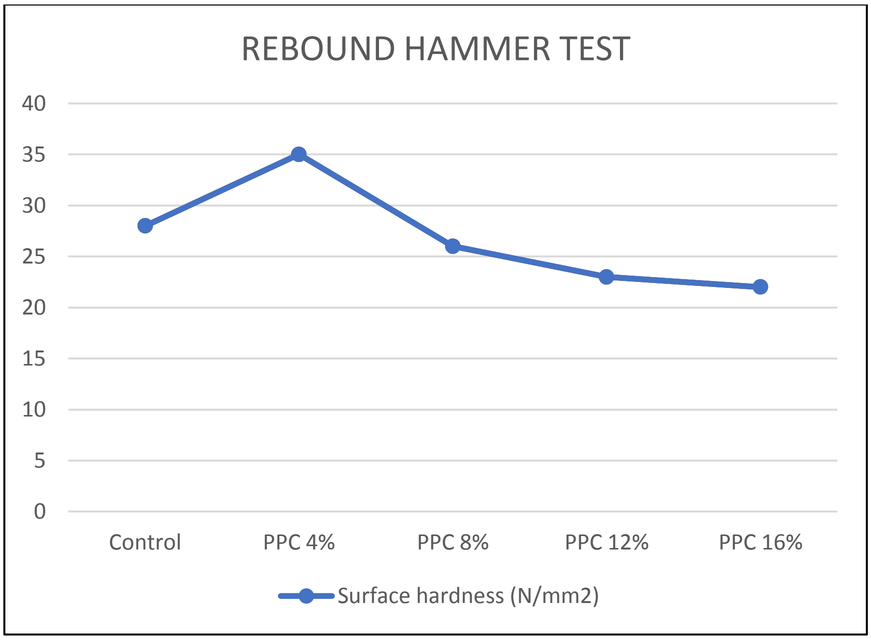


2.6. NON-DESTRUCTIVE TEST:

2.6.1. REBOUND HAMMER TEST:

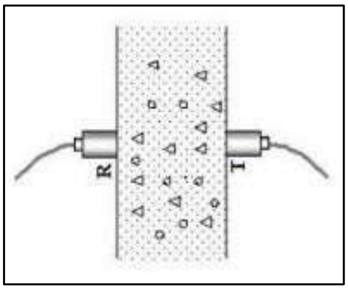
Mix	Rebound number (vertical)	Surface hardness / Compressive strength (N/mm^2)
Control	30	28

PPC 4%	34	35
PPC 8%	28.5	26
PPC 12%	26.5	23
PPC 16%	25	22



2.6.2. ULTRASONIC PULSE VELOCITY TEST:

Ultrasonic pulse velocity test is primarily used to assess the density of internal cracks formed.



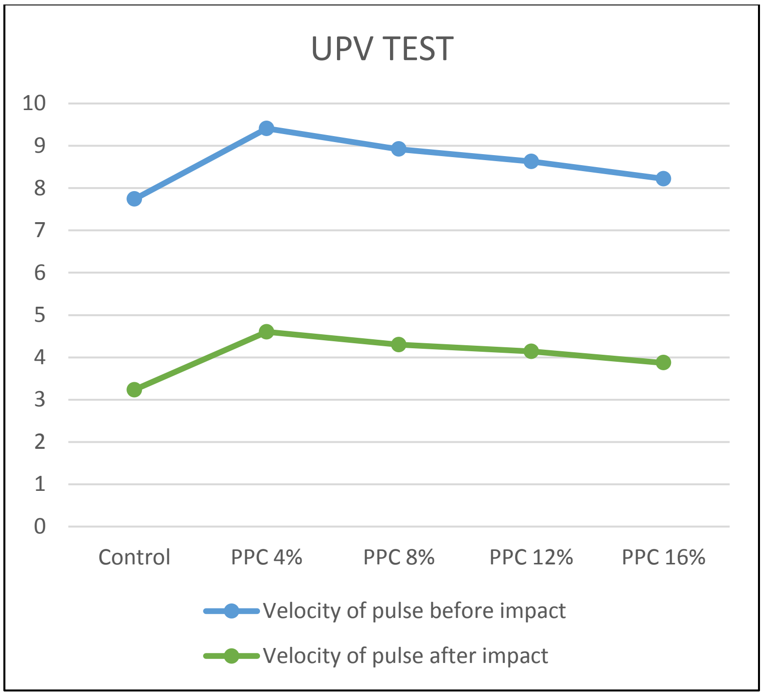
UPV ON FRESH SPECIMEN

Mix	Time taken by pulse (ms)	Velocity of pulse (km/s)	Inference
Control	22.17	4.51	Excellent
PPC 4%	20.8	4.81	Excellent

PPC 8%	21.65	4.62	Excellent
PPC 12%	22.27	4.49	Good
PPC 16%	23	4.35	Good

UPV ON LOADED SPECIMEN

Mix	Time taken by pulse (ms)	Velocity of pulse (km/s)	Inference
Control	31	3.23	Medium
PPC 4%	21.74	4.6	Excellent
PPC 8%	23.26	4.3	Good
PPC 12%	24.15	4.14	Good
PPC 16%	25.84	3.87	Good



3.CONCLUSION:

- Impact resistance is of the greatest significance when it comes to large structures that face high impact loads, because failure of those structures leads to considerable losses of life and property.
- Impact resistance of concrete was found to increase when materials used as fine aggregate were improved. Cockle seashells exhibited high binding as well as filling property, when powdered to fine aggregate sizes.

- Due to possibility of excessive heat of hydration, blended cement was used in mixes where seashell was incorporated.
- Four mixes with different replacement percentages were used; 4%, 8%, 12% and 16%. All four mixes showed greater impact resistance than conventional concrete.
- The 4% mix showed 2.5 to 3 times greater impact resistance, 25% greater surface hardness and 42.4% higher resistance to internal cracks than conventional concrete.
- The 4% fine aggregate replaced mix proved to have greater compressive, tensile, and flexural strengths than the other mixes as well as the conventional concrete.
- Furthermore, utilization of Cockle seashell concrete results in an average cost benefit of Rs. 585 when compared with conventional concrete of same grade. In addition, one cubic meter of seashell concrete uses around 25 kilograms of seashells, the management of which costs around Rs. 20,000.
- Due to its incorporation in concrete, this amount is also saved. In conclusion, Cockle seashell concrete has significantly improved impact resistance and basic strength parameters than conventional concrete.
- Its usage in construction results in considerable cost savings in the construction industry as well as the solid waste management industry. Meanwhile, it also enriches the environment by reducing the need for landfills and other disposal methods for disposing seashells.

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