



Article Title: **A Study on Cockle Seashell and Silicafume in Concrete**

A Study on Cockle Seashell and Silicafume in Concrete

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ABSTRACT

Efforts are made to incorporate by-products and their wastes from different industries as alternatives in concrete to reduce the need of virgin materials for construction purpose. Cement production is highly intensive and production cause tons of carbon dioxide (CO₂) emission every year. To overcome this crisis, pozzolanic material such as silicafume is deployed. Also, the exploitation of nature by over consumption of aggregate is increasing day by day. Fishery waste such as cockle seashell which is usually dumped or landfilled without any re-use value can be used as a partial solution for ecological, economical and environmental problems. Experimental investigations have been carried out on the use of cockle seashell as aggregate replacement materials in concrete. Seashells were utilised as partial coarse aggregates in concrete with different percentages as 10%, 15%, 20% and 25% and silicafume with different percentages as 10%, 12%, 14% and 15% of cement. This study aims to evaluate the strength properties, durability and quality of concrete using Ultrasonic Pulse Velocity (UPV) test of normal and modified mix. Strength properties such as compressive strength, split tensile strength and flexural strength were conducted for normal and modified mix. However, proper treatment such as heating at a high temperature is desirable for a better quality seashell. This presents an overview of behaviour of the cockle seashells and silicafume in concrete. It shows a higher mechanical strength and better durability compared to conventional concrete.

Keywords: Concrete, Silicafume, Cockle seashell, Compressive strength, Split tensile strength, Flexural strength, Durability test, UPV test

1 Introduction

Concrete which is the second most consumed material in the world. It is estimated that each human being uses three tons of concrete per annum. The global production of concrete is remarkably increased during the last century. It is expected that the demand for concrete will continue to rise in the future also. Different natural aggregate such as sand, gravel or crushed rock is the major constituent of concrete in terms of both volume and mass. Since annually large amount of concrete is produced, it logically follows that much quantity of natural aggregate is mined for the production of concrete. A conservative estimate of the world's consumption of aggregate exceeds 40 billion tons a year, and between 64 and 75% of the mined aggregate is used for concrete. Environmental impact during dredging, excavating and processing of natural aggregate is such a threat to river ecosystems and non-reversible land erosion. As a result of these environmental concerns, authorities in some parts of the world



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have imposed restrictions on mining of aggregate through taxation as well as banning of mining on some sites. Because of the sustainability issues associated with the production of concrete, current trends are now directed towards finding alternative sustainable materials for concrete. Many of the substitute materials used in the production of green concrete are recycled materials obtained from industrial wastes and its by-products. The aquaculture industry provides food and employment for humans and therefore plays an important role in the economy of nations. Seashell an aquaculture industrial by-product can be used as an alternative in the concrete. Untreated seashell wastes left for a long time can lead to microbial decomposition of salts into gases such as hydrogen sulphide, ammonia and amines. A promising solution to the challenge of seashell waste management is to use seashells as aggregate in concrete. Because seashells possess desirable properties, attempts have been made in using seashells as a partial or total substitute for natural aggregate in concrete. Using seashells in construction contributes to the protection of the environment in addition to preservation of natural resources. Costs are also saved when materials are re-used which range from not having to landfill or dispose waste materials and not having to source new materials. Utilising seashell by-products as recycled materials in concrete is more economical in cases where the transportation, storage and processing costs involved are more favourable in comparison with conventional aggregates. Relative abundance of molluscan seashells in coastal regions around the world indicates that the seashells are available as aggregate replacement materials in concrete. Seashells thus have the prospect of becoming important secondary aggregate sources for concrete around localities where seashells are found.

2 Test on Coarse Aggregate and Cockle Seashell

Crushed granite stones obtained from local quarries were used as coarse aggregate (Fig 4.4). The maximum size of coarse aggregate used was 20 mm. Cockle seashell maximum size of 20mm was used. Sieve analysis had been done to find the fineness modulus of aggregate. Fineness modulus of coarse aggregate and cockle seashell obtained is 6.9 and 7.3 which is within limit specified by IS2386 (part I)-1963. The physical properties and sieve analysis result of the coarse aggregate and cockle seashell has been displayed in table 1.1 and 1.2 respectively.

Table 1: Physical properties of coarse aggregate and cockle seashell

SL.NO	PROPERTIES	COARSE AGGREGATE	COCKLE SEASHELL	RANGE
1	Specific gravity	2.9	2.358	2.5 – 3.0
2	Grade zone	20 mm	20 mm	-
3	Fineness modulus (%)	6.9	7.3	5 - 8
4	Bulk Density	1542kg/m ³	1020 kg/m ³	1520 – 1680 kg/m ³
5	Void Ratio	0.91	1.296	-



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Table 2: Sieve analysis results of coarse aggregate

SIEVE SIZE (MM)	WEIGHT RETAINED IN EACH SIEVE (KG)	PERCENTAGE WEIGHT RETAINED (%)	CUMULATIVE PERCENTAGE WEIGHT RETAINED (%)	PERCENTAGE WEIGHT PASSING (%)
80	0	0	0	100
40	0	0	0	100
20	0	0	0	100
10	4.499	89.98	89.98	10.02
4.75	0.501	10.02	100	0
2.36	0	0	100	0
1.18	0	0	100	0
0.6	0	0	100	0
0.3	0	0	100	0
0.15	0	0	100	0

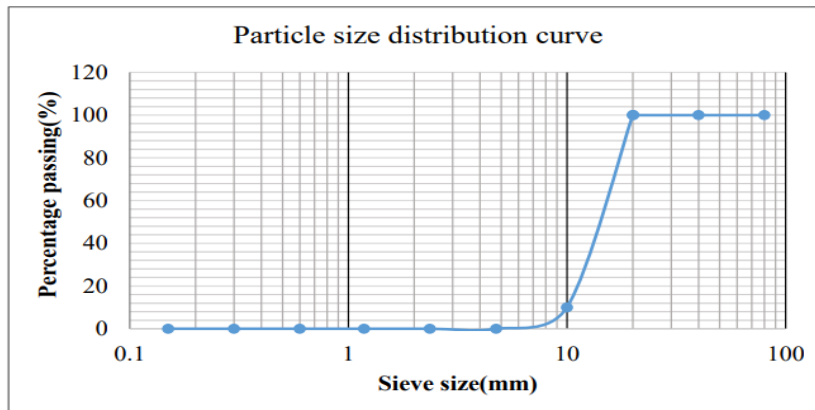


Figure 1: Gradation curve of Coarse Aggregate

Table 3: Sieve analysis results of cockle seashell aggregate

SIEVE SIZE (MM)	WEIGHT RETAINED IN EACH SIEVE (KG)	PERCENTAGE WEIGHT RETAINED (%)	CUMULATIVE PERCENTAGE WEIGHT RETAINED (%)	PERCENTAGE WEIGHT PASSING (%)
80	0	0	0	100
40	0	0	0	100
20	1.83	36.6	36.6	63.4
10	3.155	63.1	99.7	0.3
4.75	.015	.3	100	0
2.36	0	0	100	0
1.18	0	0	100	0
0.6	0	0	100	0
0.3	0	0	100	0
0.15	0	0	100	0



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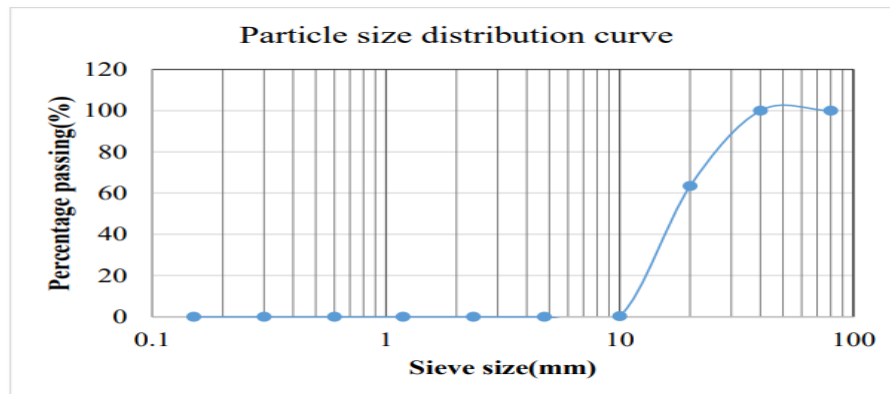


Figure 2: Gradation curve of Cockle seashell aggregate

3 Tests on Fresh Concrete

SLUMP TEST: The slump test is used to find the consistency of fresh concrete before it sets. The test procedures are simple to use. The slump test is used to ensure uniformity for different loads of concrete under field conditions. Slump cone is open at both the ends and with a diameter 100mm and 200 mm at the top and bottom. The concrete mix with different percentage of water is poured in the cone at different layers with 24 times tamping. The slump cone is lifted vertically upwards without disturbing the cone. The slump of the concrete is measured by measuring the distance from the top of the slumped concrete to the level of the top of the slump cone

COMPACTION FACTOR TEST: Compaction factor test is the workability test for concrete which is conducted in the laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. The compaction factor test is used for concrete which have low workability for which slump test is not suitable.

4 Tests on Hardened Concrete

COMPRESSIVE STRENGTH TEST: The most important mechanical test which gives an idea about all the characteristics of concrete. By this single test one judge that whether concreting has been done properly or not. For cube specimens of 150 mm x 150 mm x 150 mm is used. The concrete is poured in the mould in three layers with 25 times tamping. The top surface of these specimens should be made even and smooth. After 24 hours these moulds are removed and test specimens are put in water for curing. In this study these specimens are tested by compression testing machine after 7 days, and 28 days curing as per IS 516-1959. Compressive strength is calculated by the formula:

$$\text{Compressive strength} = \frac{P}{A} \text{ MPa}$$

Where, P = Breaking load in N; A= Area of cross section of the specimen in mm²



5 Results in Fresh Concrete

SLUMP TEST: From the test, it is observed that slump value of the normal mix, 10%, 15%, 20% and 25% replacement of cockle seashell lies in the range of 100- 150 mm (As per IS 1199-1959).

Table 4: *Slump value of cockle seashell in concrete*

Mix designation	Slump value(mm)
M30	110
10% CS	110
15% CS	105
20% CS	105
25% CS	100

The slump value of 15% cockle seashell as partial replacement of cockle seashell and varying percentage of silicafume as 10%, 12%, 14% and 15% is given in Table 7.2. It lies in the range of 100-150 represents good workability. So it can be concluded that this type of concrete is ease in preparation, transportation, placing and finishing

Table 5: *Slump value of cockle seashell and silicafume in concrete*

Mix designation	Slump value(mm)
15% CS+10% SF	105
15%CS+12% SF	105
15% CS+14% SF	105
15% CS+15% SF	105

COMPACTION FACTOR TEST: From the obtained test result, it is observed that compaction factor value of the mix lies in the range of 0.70- 0.95, represents good workability.

Table 6: *Compaction factor value*

Mix	Compaction Factor Value
M 30	0.911

6 Results on Hardened Concrete

COMPRESSIVE STRENGTH: Concrete cubes of size 150x150x150mm were tested at 7day and the values of compressive strength are given in Table 6.1. Figure 6.1 shows the variation of compressive strength for different percentages of cockle seashell.



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Table 7: Compressive strength result of concrete with cockle seashell

Mix Designation	Compressive strength (N/mm ²)		% Increase
	7 day	28 day	
Normal concrete	24.44	39.28	0
10% CS	25.10	39.44	0.42
15%CS	25.66	39.89	2
20% CS	25.00	39.40	0.38
25%CS	19.55	35.4	-9

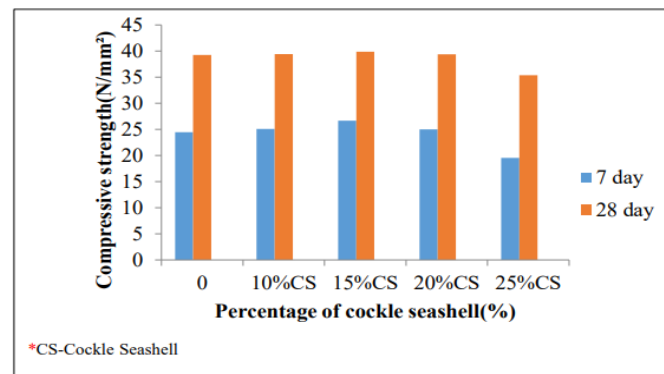


Figure 3: Graphical representation of compressive strength of concrete with cockle seashell. The optimum percentage of cockle seashell were obtained as 15% as 25.66 N/mm² at 7 th day and 39.89N/mm² at 28th day respectively. The increase in compressive strength at optimum percentage is 2% with respect to the normal M30 concrete. With optimum percentage of cockle seashell, the silicafume varied at 10%, 12%, 14% and 15%.The variation of compressive strength with cockle seashell and silicafume are shown in Table 6.3.

Table 8: Compressive strength result of concrete with cockle seashell and silicafume

Mix Designation	Compressive strength (N/mm ²)		% increase
	7 day	28 day	
M 30	24.44	39.28	-
15% CS	25.66	39.89	0
15% CS+10% SF	27.98	40.97	2.71
15%CS+12% SF	29.33	42.03	5.4
15% CS+14% SF	27.86	40.9	2.58
15% CS+15% SF	26.69	40.2	0.77



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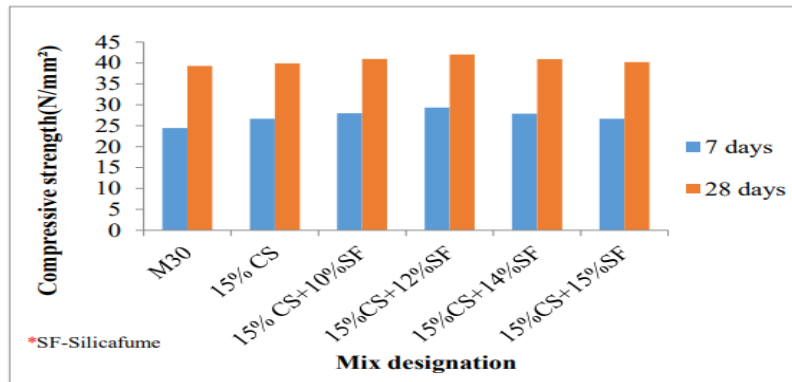


Figure 4: Graphical representation of compressive strength of concrete with cockle seashell and silicafume

The compressive strength is increased at 15% cockle seashell and 12% silicafume in concrete as 42.033 N/mm² and is compared with 15% replacement of coarse aggregate with cockle seashell.

7 Conclusion

The study is based on the partial replacement of cockle seashell as coarse aggregate with varying percentage of 10%, 15%, 20% and 25% in concrete. In order to improve the strength properties of this concrete, silicafume is used as partial replacement of cement with 10%, 12%, 14% and 15% along with optimum percentage of cockle seashell. Mechanical properties such as compressive strength, split tensile strength and flexural strength were conducted. Durability and UPV test were also conducted. From the study, it is concluded that: The optimum percentage of cockle seashell was obtained as 15%. The optimum percentage increase in compressive, split and flexural strength of cockle seashell concrete was 2%, 27.7% and 10.7% respectively with respect to the normal concrete. The increased behaviour is due to the rough surface of cockle seashell. The optimum percentage of silicafume was obtained as 12% with 15% cockle seashell concrete. The optimum percentage increase in compressive, split and flexural strength of concrete mix with 12% silicafume and 15% cockle seashell obtained as 5.4%, 9.1% and 29.1% respectively with respect to the cockle seashell concrete. Due to increased properties of concrete with cockle seashell and silicafume, it can be used for construction of structural members. The ultimate load carrying capacity of modified beam (15% cockle seashell and 12% silicafume as partial replacement of coarse aggregate and cement in concrete) is higher than normal specimen whereas the deflection of modified beam was less than that of the normal beam specimen. The first crack load and ultimate load of modified mix were greater for the conventional beam. First crack and ultimate load for normal beam is 50 kN and 120 kN whereas for modified beam is 55 kN and 140 kN respectively. The percentage increase in ultimate load carrying capacity for modified beam found to be 16.67 % compared to the conventional beam. Modified concrete shows better resistance to acid attack and alkali attack



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compared to normal concrete. The percentage weight loss and strength loss for the modified mix is less than that of the normal M30 mix. The partial replacement of silicafume and cockle seashell as cement and coarse aggregate will give durable concrete. UPV test shows the pulse velocity of the modified mix having an excellent quality that is free from the pores and voids. From the experimental study, it can be inferred that incorporating silicafume and cockle seashell as partial replacement of cement and coarse aggregate in concrete has improved performance than normal mix.

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