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Research paper

Investigating possibilities for using sea shell on compressive strength properties of concrete

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Abstract

The reason of this attempt was to demonstrate that seashells can be utilized as a partial replacement for fine aggregate in concrete for enhancing strength properties. Since seashells are widely available everywhere in coastal and seashore areas, and some of the concrete materials cannot be found easily everywhere. The strategies utilized as a part of this attempt was to replace burnt and crushed seashells with fine aggregate at 10%, 20% and 30% and compare it with each other and the traditional Ordinary Portland Cement concrete regarding mechanical properties following 7 and 28 days. In conclusion, despite the fact that seashells are generally accessible and can be effortlessly gathered from seashore and beach front regions, the process of burning and crushing requires a lot of energy and is tedious. In spite of the fact that the results demonstrated that utilizing 20% seashell to fine aggregate substitution has a somewhat higher in compressive and flexural properties than that of Ordinary Portland Cement concrete.

Keywords: *Seashell; Sustainability; Fine Aggregate; Mechanical Properties; Supplementary Material.*

1. Introduction

Concrete is viewed as the most famous artificial material utilized on Earth, as it is utilized wherever individuals may be, and is viewed as a need for building a protected natural surroundings that can withstand a high scope of various temperatures and weathering, for example, snowing, raining and wind. Concrete is also considered cheap when being compared to different materials that may be used for the same purpose such as aluminum, steel or plastic. Concrete is not referred to as a single material, it can be a different number of materials and substances that mix up or combine with aggregates and binding materials to form a strong bond. The basic materials used in any conventional concrete are water, cement, fine aggregate and coarse aggregate. Cement plays crucial role in bonding the concrete whereas aggregate plays crucial role in availing the strength of concrete. To increase the strength, concrete is usually reinforced with different elements such as steel or admixtures that could be added when concrete mixing and moulding. Around 70-80% of aggregate is present in concrete. Sea shells are usually found in seashores and valleys as they are created from marine animals that live in the sea to act as a protective shield, to be specific, they are the exoskeletons of mollusks like oysters, clams and snails, they usually have hard-protective outer layers, these layers are made up mostly of calcium carbonate with a small percentage of proteins [1]. Seashells are usually considered redundant and cannot be used as a key ingredient for manufacturing purposes. The chemical composition of seashells has proven that they can be used as a partial addition to the usual fine aggregate we currently use like sand and crushed stones, since the main oxides used in both, seashells and fine aggregates/cements are very much similar, as they all contain big percentages of Calcium Oxide, Silicon Oxide and alumina. According to the studies of Oliviaa M. et. al [2] on the mechanical properties of seashell concrete using seashells as a partial replacement to cement and comparing the results in terms of compressive strength, tensile strength, flexural strength and modulus of elasticity to conventional ordinary Portland cement concrete. They replaced cement with sea shells (0%, 2%, 4%, 6% and 8%) and casted number of samples to determine strength properties for the period of 7, 28 and 91 days. Finally it can be concluded that the concrete containing ground seashell yielded relatively better tension properties, but lower compressive strength and modulus of elasticity than the control concrete". The Young's Modulus of Elasticity of seashell concrete increased with the age of concrete. According to Kumar et. al [3]. Which is very much related to this study as it talks about the effects of using seashell as a partial replacement of concrete raw materials and comparing the results in terms of compaction factor, compressive strength, tensile strength and slump test to conventional concrete. The methodology used in their study is that they made four samples for each test, one control sample and the three others had 10, 20 and 30% coarse aggregate replaced by seashell and cement replaced by lime and determined workability of the concrete, compaction factor the compressive strength and tensile strength .The final results show that the " the strength is same with the conventional concrete only at 10% and 20% replacement of aggregate by sea shell .The strength is gradually decreasing at 30% replacement of sea shell" and they concluded that replacing lime partially with cement and adding seashell to coarse aggregate is suitable for construction, and it also helps reduce construction costs by reducing the amounts of ordinary OPC materials used and reduced environmental pollution. Mageswari. R. et. al. [4] determined the compressive strength in using seashell as an admixture to the conventional concrete by replacing cement partially with fly ash to 25% and coarse aggregate with seashell to 10%, 20% and 30% by weight. The methodology of this study includes water Absorption test, specific gravity of aggregates, slump test and compressive strength and concluded that based on the results taken after 14 days showed that the conventional OPC had the highest compressive strength compared to the three other moulds

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which contained 10, 20 and 30 % seashell concrete mixes respectively. Although the 10% mould is closer in terms of compressive strength to the conventional concrete which shows that it can be used in construction but failing to prove the main scope of the study in that it helps increase the overall amount of strength in concrete. The studies of Bharathi et. al. [5] made partial replacement of coarse aggregate and fly ash as a partial replacement of cement and find the mechanical properties in order to establish the optimum percentage of seashell and fly ash to use in construction. The replacement of seashell lowered the flexural strength and the seashells were replaced the work. The substitution of seashell brought down the flexural quality and the seashells were supplanted the workability diminished to the harsh surface of the seashell concrete ability decreased to the rough texture of seashell concrete. Overall the use of seashell and fly ash as partial replacements proved that they can reduce the construction costs of cement and reduce environmental pollution due to using seashell and fly ash. According to Vignesh S [6] in order to determine usage of seashell and fly ash partially will help in reduce the cost of concrete. Based on his experimental for 7 and 14 days and concluded that strength decreases with percentage of replacement increases. However, replacement by 10% and 20% is found to be more than the conventional concrete and 30% replacement is found much slightly lower than expected. As per Chakravarty H.G et. al. [7] to analyze the effects of seashells in concrete production of high strength concrete. They casted concrete specimen and found out strength properties and workability tests. In conclusion, this experiment found that the partial replacement of seashells to coarse aggregate is good as it reduces the buildup of marine organic waste on the seashores and avoid using natural resources like granite and sand which lower the cost of concrete material. Dixit et. al.[8] Studies speaks about a similar topic of present study, the difference is that they replaced municipal solid waste bottom ash from incinerator with fine aggregate, then started to compare with the conventional concrete in terms of compressive strength, split tensile strength and workability. The common factor here is the compressive strength. The results show that after 7 days, the concrete mixes were fairly similar, yet after 28 days it clearly indicates that M5 (20% Replacement of Fine Aggregate in Concrete with Municipal Solid Waste Bottom Ash from Incinerator) had the highest compressive strength, meaning that municipal solid waste bottom ash from incinerator can be used to suit designs that require more strength. In conclusion, it was observed that the fine aggregate that was replaced by 50% had the strongest compressive strength after 7 and 28 days. The similarity to the project made by Etuk et. al. [9] they used seashells in the concrete as an admixture. The materials in this project were periwinkle, snail and oyster shells, OPC, water and sand. The shell samples were then washed and dried for three days. They were kept into a furnace until ashed at temperatures of 800 °C for four hours. Afterwards it was prepared into a powder and sieved through a sieve of 63 microns, and then put into containers for analyses. Afterwards the seashells went through a chemical analysis in the analysis stearic acid 0.4 g and 20.0 g of the three types of shell ashes collected at temperatures of 800 °C were measured and grounded for 60 seconds using the Herzog grinding machine. The ash samples afterwards had a specific gravity analysis and also they had to determine the consistency of cement pastes before finally being put into the cube molds of 50x50x50 mm and given enough time to settle. This study done by Dang Hanh Nguyen et. al. [10] explained about usage of seashell in different forms or by-product including concrete mixes then comparing the concrete mixes in terms of compressive strength. The methodology of this includes replacing coarse aggregate of the conventional concrete with 20%, 40% and 60% of SBP (Sea Shell By-Product).by mass. A total of 15 cubic molds were casted, each of sizes 15cm X 15cm X 15cm. Different tests were done including compressive test, tensile test, slump test and water permeability test. 8 mixtures were casted for the compressive strength; the test results shows the concrete based on shells are the same to that of the control concrete but with lower strength and all concrete mixes have a firm consistency. Also water permeability increases with porosity increases showing a strong relationship between water porosity and mechanical strength. Shape and texture of aggregate is one of the major parameter that influence the properties of fresh and hardened state of concrete [11].In their work, effect of aggregate on strength properties of concrete was studied. According to previous studies on the present topic, it found that there is lack of research work in the present era. Thus a detailed experiment has been carried out on the mechanical properties of seashell concrete as a fine aggregate by using varied the percentages of seashell content. Few studies mentioned on partial replacement with coarse aggregate and fine aggregate (up to 20%). The experiment proposed in present study is expected to show results on how to produce better results in terms of using seashells as a partial replacements. This attempt can hopefully be used to help local concrete makers to realize the potential of using seashells as a partial local replacement in construction. This literature will helps to study the mechanical characteristics of new concrete using sea shell in different proportions and gains knowledge on utilization of sea shell in profitable manner as supplementary cementitious materials (SCM)

2. Materials used

The different materials used in this investigation are-

2.1. Cement

Ordinary portland cement (OPC) 53 grade cement was used in this investigation. Few tests like initial setting time, Specific gravity and fineness of cement are caluculated

2.2. Fine aggregate

Zone 2 sand has been used in this experimental program . Consists of small natural gravel and sand that have been sieved to remove particles larger than 5 mm and is due to be used to reduce the amount of cement required for the production. The fine aggregate was collected from the MEC campus, and was sieved by using 4.75 sieve until reaching the required weight.

2.3. Coarse aggregate

Machine crushed granite has been used in this experimental program . The coarse aggregate has been collected from MEC campus and sieved using 20 and 14 mm sieves from the MEC laboratory.

2.4. Water

The water that is used in the concrete mixing should be pure that means it shouldn't have any colour and smell. Water mixes the concrete mixture properly and binds its components. The water quantity controls many characteristics, such as: compressive strength, workability, water tightness, permeability, and durability.

2.5. Admixture (conplast SP430)

To improve the workability, admixture is used 0.5% of cement weight.

2.6. Sources of procurement

Materials that are required for this work are purchased at nearby source

2.7. Sea shell

Seashells can be easily found everywhere at marine & coastal areas due to its rich properties. Seashells are used for different purposes such as decoration, Jewellary and sometimes as concrete

admixtures. It was burned to kill any organic compounds and crushed as shown in Fig. 1 at Al misfah industrial zone which is located in Alansab at a steel and aluminium workshop. The seashell was sieved using 4.75 sieves similar to the ones used for the fine aggregate.



Fig. 1: The Burned and Crushed Process of Seashell.

3. Methodology

This attempt is done to determine the effect of seashells on concrete properties. In this work, consideration is focused on the compressive strength which is linked to other properties such as durability in the laboratory, all the required materials are mixed in rotary mixing machine with addition of required quantity of water for 3-5 minutes. The cubes were casted with partial replacement of sea shell with 10%, 20% and 30% and found out strength properties. The mixed fresh concrete is poured into the moulds. Make sure top surface is well finished and the sizes of the specimens like cube moulds (150mm x 150mm x 150mm. The casted specimens are demoulded after 24 hours and are kept in different curing regimes. The specimens cured in water for 7 and 14 days

4. Results and discussion

Through compressive strength experiments which are done for this project, values are observed how replacing the fine aggregate with seashell will affect the compressive strength of concrete. According to our results and of previous studies, we have concluded that the compressive strength of concrete increases with the amount of replaced seashell, but this increase usually just applies to specific amounts. However, in our experiments we have compared three different percentages of partially replaced seashells which are 10, 20 and 30% during two different times of curing, 7 and 14 days. However, we divided the laboratory work into 4 experiments.

Table 1: Compressive Strength of Conventional Concrete

Cube	Sea shell replaced	Days	Maximum load (KN)	Strength (M Pa)	Average (Mpa)
R0-1	10%	7	983.06	43.69	
R0-2	10%	7	952.300	42.32	43.376
R0-3	10%	7	992.74	44.12	
R0-4	10%	14	1084	48.18	
R0-5	10%	14	1198.81	53.32	50.06
R0-6	10%	14	1095.41	48.68	

From the results obtained for conventional concrete, it is noticed that compressive strength for concrete cubes R0-1, R0-2 and R0-3 are as following 43.69, 42.32 and 44.12 Mpa respectively and the average was 43.376 Mpa, these values are after 7 days of curing. After curing 14 days of same type of cubes R0-4, R0-5 and R0-6 the compressive strength was 48.18, 53.32 and 48.68 Mpa and the average is 50.06 Mpa as shown in Table 1. According to these results. In 7 days cured concrete the maximum value of maximum load was 1031.033 KN while in 14 days cured concrete the maximum value of maximum load was 1195.36 KN.

Table 2: Compressive Strength of Concrete with 10% Replacement with Seashell

Cube	Days	Maximum load (KN)	Strength (M Pa)	Average (Mpa)
R10-1	7	996.187	44.27	
R10-2	7	1031.033	45.82	44.75
R10-3	7	994.178	44.18	
R10-4	14	1088.03	48.35	
R10-5	14	1121.22	49.83	50.43
R10-6	14	1195.36	53.127	

From the results shown in Table 2, After 7 days of curing, the compressive strength of seashell concrete cubes replaced with 10% fine aggregate with seashell R10-1, R10-2 and R10-3 was 44.27, 45.82 and 44.18 Mpa and the average strength was 44.75 Mpa, after curing 14 days of same type of mixture of cubes R10-4, R10-5 and R10-6, the compressive strength was noticed that 48.35, 49.83 and 53.127 Mpa respectively and the average is 50.43 Mpa. According to these notes, the compressive strength of seashell concrete become more after 14 days of curing compared with 7 days of curing. The increasing in maximum load of 10% seashell cubes has behaved like the conventional concrete cubes, it increased significantly until concrete break time and it is more than the conventional as shown in Table no.2.

Table 3: Compressive Strength of Concrete with 20% Replacement with Seashell

Cube	Sea shell replaced	Days	Maximum load (KN)	Strength (M Pa)	Average (Mpa)
R20-1	20%	7	1046.37	46.5	
R20-2	20%	7	1018.198	45.25	45.664
R20-3	20%	7	1017.98	45.243	
R20-4	20%	14	1106.95	51.20	
R20-5	20%	14	1158.72	49.198	50.62
R20-6	20%	14	1152..13	51.49	

In experiment no.3, it is recorded that compressive strength with 20% replaced seashell concrete cubes R20-1, R20-2 & R20-3 are 46.50, 45.25 and 45.243 Mpa respectively and the average was 45.664 Mpa, these values are after 7 days of curing. After curing 14 days of same type of cubes R20-4, R20-5& R20-6 the compressive strength was 51.20, 49.198 and 51.49 Mpa and the average is 50.62 Mpa as shown below in Table no.3. According to these notes, the compressive strength of 20% seashell concrete become more than 10% seashell concrete and conventional concrete results.

Table 4: Compressive Strength of Concrete with 30% Replacement with Seashell

Cube	Sea shell replaced	Days	Maximum load (KN)	Strength (M Pa)	Average (Mpa)
R30-1	30%	7	1038.84	49.44	
R30-2	30%	7	1085.37	48.23	47.946
R30-3	30%	7	1112.62	46.17	
R30-4	30%	14	1080.21	48.009	
R30-5	30%	14	1078.21	47.900	47.77
R30-6	30%	14	1066.522	47.400	

In experiment no.4 the compressive strength of seashell concrete cubes replaced with 30% of fine aggregate with seashell are R30-1, R30-2 & R30-3. After 7 days curing the values are as follows 49.44, 48.23 and 46.17 Mpa and the average was 47.946 Mpa and after curing done for 14 days for the same type of cubes R30-4,

R30-5& R30-6 the compressive strength was noted that 48.009, 47.92 and 47.400 Mpa and the average is 47.77 Mpa.

5. Conclusion

The compressive strength of concrete using seashells as a partial replacement for fine aggregate is found that using 20% replacement of fine aggregate is the most suitable amount to prepare hard concrete and it is observed that strength after 14 days for conventional concrete is 50.06 Mpa. Whereas compressive strength with 20% replacement is 50.62 Mpa Also it can be seen that replacement with 10% is 50.43 which is more than conventional concrete 50.06, but lower than strength with 20% replacement.
According to sustainability point of view, it can be concluded that partial replacing seashells with fine aggregate is a very good substitute to using conventional fine aggregate as it increases the compressive strength and can help reduce construction costs overall since seashells are widely available in Oman and it will also reduce the organic waste left at seashores by seashells which in turn helps the environment.

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