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INVESTIGATION OF PROPERTIES OF CONCRETE WITH SEASHELLS AS A COARSE AGGREGATE REPLACEMENT IN CONCRETE

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Abstract

This paper represents the experimental results of a concrete using seashell as a partial replacement. The present work is to investigate the effects of seashells in concrete production to produce high strength concrete. The compressive strength, flexural strength and split tensile strength tests were carried out with different proportioned sea shells at different curing days, as well as finding the optimum percentages of sea shell replacements to give targeted strengths.

The concrete samples were prepared by adding seashells about 0%, 10%, 20%, 30% and 40% as a partial replacement to coarse aggregate. All these samples were cured for 7 days, 14 days and 28 days before the compressive, split tensile and flexural test were carried out. A total of 135 specimens were casted and tested for five mixtures in their proportions so as to determine the mechanical properties of the concrete. It should be noted that no additives were added to the mix except sea shell as a partial replacement coarse aggregate. A total of 45 cubes were casted for compressive strength test with dimensions of (150mm x150mm x150mm) and 45 *prisms were casted for flexural strength test with dimensions of (100mm x100mm x300mm) and remaining 45 cylinders casted for split tensile strength test with dimensions of (100mm x200). After these tests were carried out, the results were used to compare with those of the control experiment. The results showed a decrease in density due to increase in seashell content and a high strength value obtained for 20% replacement. It was noted that implementing seashells in the concrete mix can be used to produce a lightweight concrete with high strength.*

Keywords

Coarse aggregate, Seashells, compressive strength, flexural strength, split tensile strength.

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1. Introduction

In this research work properties of structural concrete when seashells are used as coarse aggregate replacement were studied. Most of the waste materials are non-bio degradable and may remain on the environment for hundreds or even thousands of years. These non-biodegradable materials causes waste disposal crisis leading to environmental problems. The problems of waste materials accumulation is everywhere around the world and mostly affect high density areas. According to research from (Waste Management., 2007) use of these industrial and marine waste products can be of great advantages in the construction industries. Utilizing seashells reduces the storage of marine waste, also reducing exploitation of quarried aggregates and has benefits in adding different materials to a concrete mix design for improved performance (Richardson & Fuller, 2013).

The aim of this research work is to

- To make an investigation on the workability of freshly mixed concrete. This will be achieved by carrying out slump test and compaction factor test.
- To make an investigation on the durability of hardened concrete using the compressive, tensile and flexural strength test.

2. Selection of material

Preparation of sea shells;

Since seashells are from the sea, there is high probability of them being contaminated by the salts of the water and also in biological nature. Preparation of seashells include

- Washing the seashells in cold water for the first time.
- Washing in warm water with vinegar added in it.

- Placing them outside to dry in sunlight.

The dried seashells are taken to the laboratory for crushing. Sieve analysis test conducted and all the shells that do not pass through the 4.75mm were considered as coarse aggregates.

The seashells used for this work were obtained from a local fisheries industry in Port Dickson Malaysia.

Cement; Cement is a material which is used to bind solid bodies together by hardening from a fresh or plastic state. In this research work locally available ordinary Portland cement was used.

Coarse aggregate; The coarse aggregate was air dried to obtain saturated surface dry condition to ensure that water cement ratio was not affected. Few characteristics of aggregate that affect the workability and bond between concrete matrixes are shape, texture, gradation and moisture content. In this study crushed aggregates from quarry with the nominal size 5-10 mm were used in accordance to BS 882-1992.

Fine aggregate; Fine aggregate is commonly known as sand and should comply with coarse, medium, or fine grading needs. The fine aggregate was saturated under surface dry conditions to ensure the water cement ratio is not affected. The oven dry sand will then be sieved sand passing through the 600µm used for this test.

Water; the chemical reaction between water and cement is very significant to achieve a cementing property. Hydration is the chemical reaction between the compounds of cement and water yield products that achieve the cementing property after hardening. Therefore it is necessary to that the water used is not polluted or contain any substance that may affect the reaction between the two components, so tap water will be used in this study.

3. Concrete mix design

The present experimental research program was conducted to determine the effect of silica fume on properties of concrete. Experiments performed only for cement replaced by different percentages of silica fume and all the other mix design variables like amount of aggregates, water content and super plasticizer proportions were kept constant. In this work the following ratio used for mix design (cement, sand, coarse aggregate) is 1.2:1:1.5. The mix proportions were summarized in table 1.1.

Table 1.1: *Mix proportion*

	Cement (kg/m^3)	Sea shells (kg/m^3)	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (kg/m^3)
Sea shells (0%)	589.4	-	614.33	940.03	230
Sea shells (10%)	589.4	94.15	614.33	595.66	230
Sea shells (20%)	589.4	141.13	614.33	543.58	230
Sea shells (30%)	589.4	235.28	614.33	479.62	230
Sea shells (40%)	589.4	377.16	614.33	383.77	230

4. Tests on Fresh Concrete

Slump test

Slump test is the most common method used for measuring the workability of a freshly mixed concrete. To be more specific, the test measures the consistency of the concrete mix in a specified batch. The consistence of concrete refers to the ease at which it can flow hence the test is used to determine the degree of wetness. According to (Gambhir, 2004) the mixes which are wet are more workable than those which are dry. The slump test results are tabulated in table 1.1.

Table 1.2: *Slump test results*

Sea shell content (%)	Slump value (mm)
0	50
10	46
20	39
30	34
40	20

Compaction factor test

Compaction factor test is done to determine the degree of compaction which is achieved by a standard of work done by letting the concrete to fall through a standard height. Density ratio is used to determine the degree of compaction. This method is commonly used in the laboratory or in the field using concrete of high, moderate or low workability (Gambhir, 2004).

The purpose of the test is to give us the degree of compaction that is achieved by a standard amount of work done this will give us an indication on the workability of the concrete. The compaction test results are as shown in table 1.3.

Table 1.3: *Compaction factor test results*

Sea shell content (%)	Compaction factor value (mm)
0	0.897
10	0.835
20	0.811
30	0.789
40	0.746

5. Tests on hardened concrete

Compressive strength test

The compressive strength of concrete specimens is taken as maximum compressive load it can carry per unit area. The specimen usually in the form of a cube is compressed between the platens of a compression testing machine by a gradually applied load. The compressive strength test was carried out on 100 x 200 mm concrete cylinders in accordance with the BS 1881: part 116.

As shown in the table 1.4, the first column shows 0% replacement representing normal concrete followed by 10%, 20%, 30%, and 40% seashell content. After the concrete was casting in molds it was cured for 7 days, 14 days and 28days. Three samples were cast for each mix giving three compressive strength values which were averaged to give the average strength. The tables that follow show the full calculated values of the respective strength which are further illustrated by figures below.

Table 1.4: *Compressive strength test result at the age of 7, 14 and 28 days*

Concrete Mixes	Compressive Strength (N/mm^2)		
	7 days	14 days	28 days
Sea shells (0%)	30.49	38.24	45.45
Sea shells (10%)	26.79	34.83	37.32
Sea shells (20%)	33.87	42.92	48.96
Sea shells (30%)	24.68	27.69	29.44
Sea shells (40%)	24.13	26.40	27.66

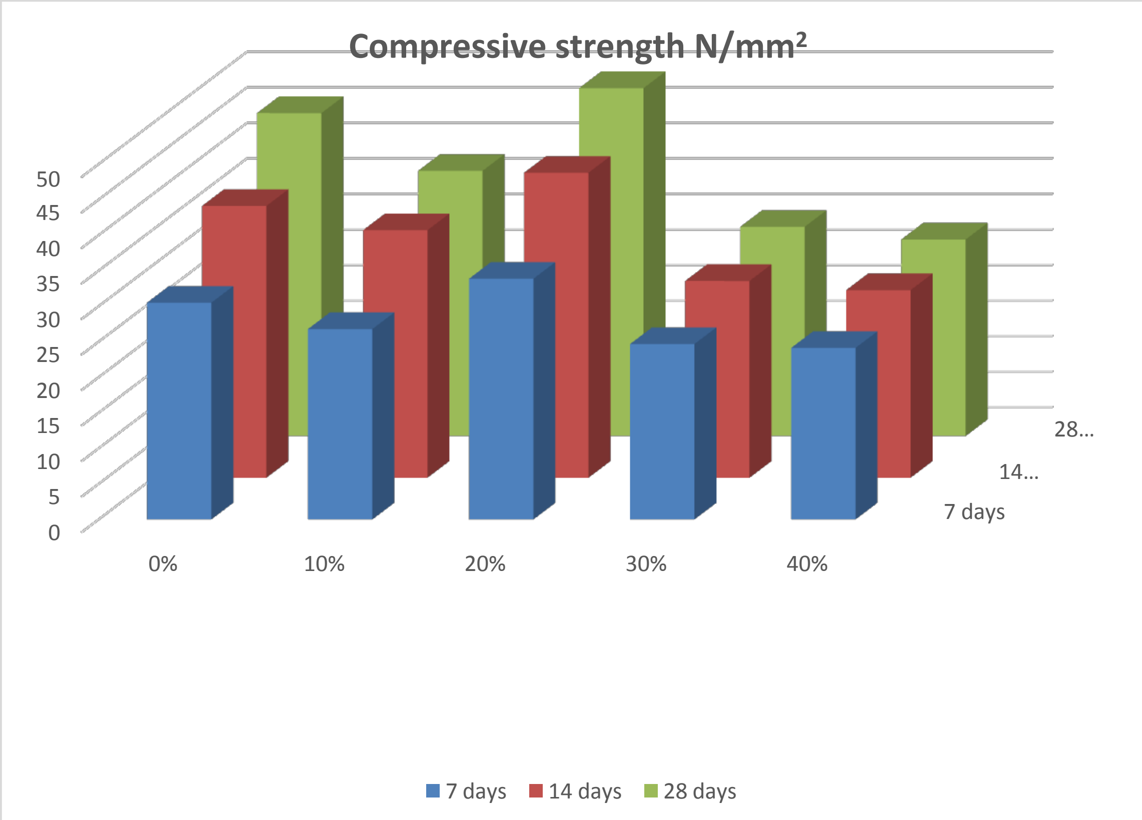

Figure 1

Flexural strength test

Flexural strength test is conducted on unreinforced concrete beam or slab to resist failure in bending. The flexural strength is expressed as modulus of rapture in (Map). For this research work, flexural strength (modulus of rupture) was determined by centre point loading during which the concrete beam was placed on two rollers and the entire load was applied on its centre. For this research work silica fume was used to investigate its effect on the flexural strength of concrete. Flexural strength test was conducted on 100 x 100x 350 mm beams at the age of 7, 14, 28 days. Each strength value obtained is actually the average of values of three specimens.

Table 1.5: *Flexural strength results*

Concrete Mixes	flexural Strength (N/mm^2)		
	7 days	14 days	28 days
Sea shells (0%)	5.63	5.76	6.2
Sea shells (10%)	5.18	5.22	5.74
Sea shells (20%)	5.99	6.39	7.95
Sea shells (30%)	4.94	5.28	5.86
Sea shells (40%)	4.93	5.22	5.76

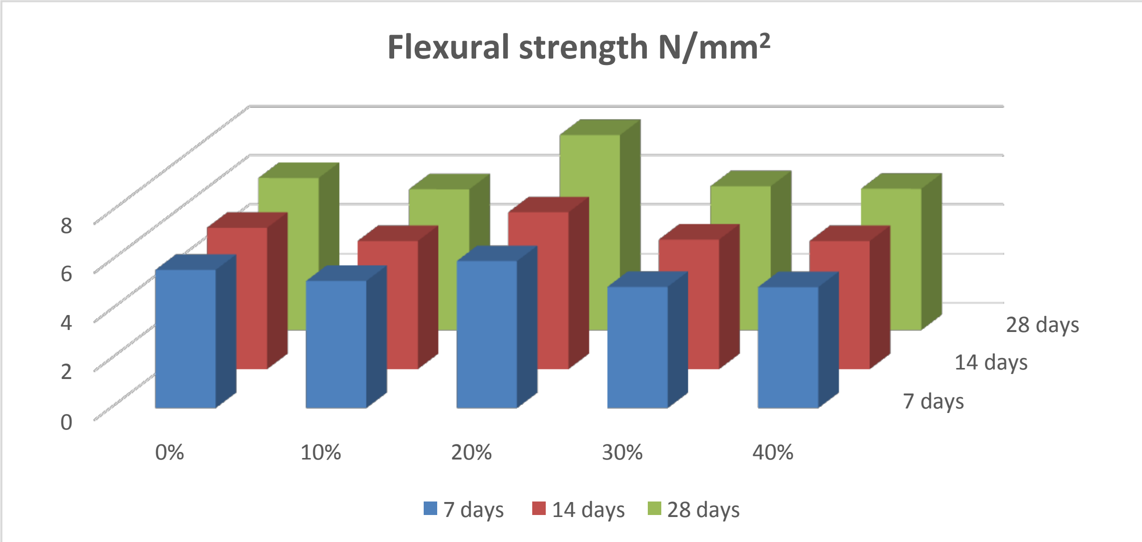

Figure 2

Split-tensile strength test

Tensile strength is one of the important properties of concrete. Generally is unusual for concrete to resist direct tension this is because of its lower tensile strength and its brittle nature. Determination of the split tensile strength is very important for us to determine the amount of load at which the concrete will crack or break completely. This method consists of A concrete cylinder measured 200mm by 100mm diameter is placed in a compressing machine and load applied vertically from the top to the bottom. Plywood or cardboard is added between to ensure even loading.

Table 1.6: *split tensile strength results*

Concrete Mixes	flexural Strength (N/mm^2)		
	7 days	14 days	28 days
Sea shells (0%)	5.63	5.76	6.2
Sea shells (10%)	5.18	5.22	5.74
Sea shells (20%)	5.99	6.39	7.95
Sea shells (30%)	4.94	5.28	5.86
Sea shells (40%)	4.93	5.22	5.76

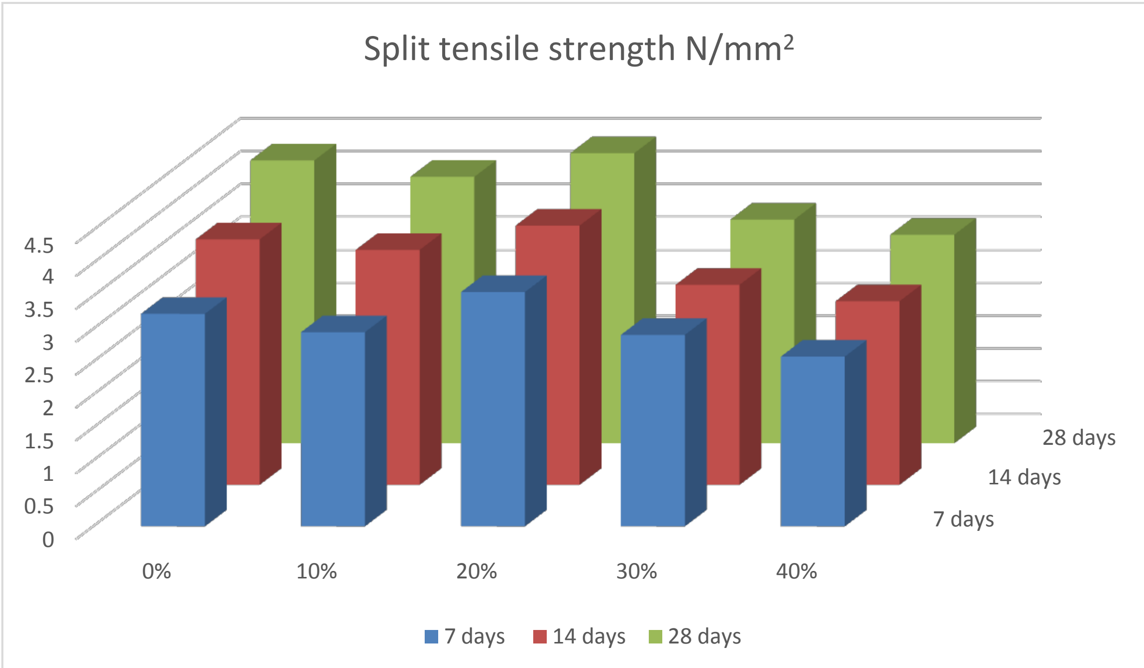

Figure 3

6. Conclusions

Generally using seashells as partial replacements in concrete is very good, as it reduces the depletion of natural resources like sand and granite, it also reduces accumulation of waste marine materials on rivers or sea beds and banks. From the study the following conclusions were brought forth

- In early stages of the analysis it was found that adding and increasing the seashells as partial replacement reduces the workability of concrete.
- The density of the concrete was observed to be decreasing as the content of seashells was increased from 0% to 40%. At day 28 the samples that contained seashells showed densities between 2144 kg/m^3 - 2284/m^3 and that of concrete with a highest value of 2307kg/m^3.
- As the percentage of seashells was increased from 0% to 40%, it was observed that maximum strength was observed at 20% replacement in all compressive, flexural and split tensile tests.

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