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A STUDY ON THE INFLUENCE OF SPENT CATALYST AND SEASHELLS IN CONCRETE

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Abstract : Concrete is widely used in domestic, commercial, recreational, rural and educational construction. Concrete basics aim to provide a clear, concise explanation of all aspects of making quality concrete from the materials and properties involved through planning, preparation, casting and curing. Concrete is mixture of cement, coarse, fine aggregates and water. The aim of this research is to determine the influence of spent catalyst and seashells in concrete replacing cement and coarse aggregate. The objective of this study is to analyze the behavior of concrete using seashells and spent catalyst and to compare between the normal concrete and concrete mixed with seashells and spent catalyst. Cement was partially replaced in (10%, 15% and 20%) with spent catalyst and Coarse Aggregate was partially replaced in (5%, 10%, and 15%) with seashells. Cubes were cast in mould with dimension (150mm x 150mm x 150mm) using mix design calculation for C30 grade which was done according to ACI method. The result show that the compressive strength is increased up to 15 percent replacement of cement and coarse aggregate with spent catalyst and seashells for 28 days. The addition of spent catalyst and seashells has positive effect on the compressive strength of cube.

***Index Terms*: Spent catalyst, Seashells, Compressive Strength, Coarse aggregate, Mix design**

I. INTRODUCTION

Concrete is a hardened building material created by combining a chemically inert mineral aggregate (usually sand, gravel, or crushed stone), a binder (natural or synthetic cement), chemical additives, and water. Although people commonly use the word "cement" as a synonym for concrete, the terms in fact denote different substances: cement, which encompasses a wide variety of fine-ground powders that harden when mixed with water, represents only one of several components in modern concrete. Spent catalyst is generated as a waste material around the world from the cracking of petroleum in oil refineries. The disposal of spent catalyst is of major concern to oil refineries. In Oman, there are two types of spent catalysts generated by refineries: reduced fluid cracking catalyst RFCC and spent alumina catalyst SAC (Siham ,Shahjahan and Anna, 2013).

Seashells are partial remains of dead animals. Enormous quantities of shell waste are illegally abandoned on maritime coasts, or are incinerated in factories, which also cause pollution and destruction to the environment. Several studies have been carried out to investigate the feasibility of using shell waste in the field of civil engineering as a partial or total alternative to aggregates, sand or cement.

This research focuses on the influence of spent catalysts and seashells in concrete. In this study the preliminary tests on materials are done and the required mix (C30) is designed as per ACI method. Spent catalyst one of the admixtures is being used to replace cement partially by weight in various proportions (10%, 15% and 20%). also seashells used to replace coarse aggregate partially by weight in various proportions (5%, 10%, 15% and 20%). In the experimental study 30 cubes were cast and cured for 28 days and their compressive strength was tested using UTM. The aim of this study is to determine the influence of seashells and spent catalyst in concrete replacing coarse aggregate and cement. The objective of this research is to obtain the properties of ingredients of concrete and compare the compressive strength of conventional mix with that of concrete replaced with sea shells and spent catalyst.

II. Literature Review

In this research use of spent catalyst (SC) and seashells (SS) as partial replacement for cement and coarse aggregate in concrete is found through experimental work. The strength of SS and SC mixed concrete is measured and compared with normal mix and the optimum percentage of SS and SC replacement is obtained.

"To increase the Strength of Concrete by adding Seashell as Admixture". The objective of this study is, to compare the strength of concrete specimen mixed by conventional method with that of specimens mixed by replacing cement partially with fly ash to 25% and coarse aggregate with seashell to 10%, 20% and 30% by weight also to reduce the demand of cement moreover, to improve the durability of the concrete and to find the optimum strength of the partial replacement of concrete. The experimental work, concrete samples were prepared and compared with the criteria in their codes after that done the Tests such as: Compressive strength of concrete cubes were is conducted on 14 day and 28 day. Finally, note the results of these tests. The results of this study as following: "The slump obtained for each seashell concrete design mix and conventional design mix is suitable for construction purpose and also has a good workability. Also, Water absorption is 2%. The results of the aggregates tested are 1% for sand, 0.5% for 20 mm aggregates and 0% for seashell" (Maheswari, Manoj and Princepatwa, 2016).

Nahushananda and Tatenda (2015) discussed the effects of seashells in concrete production to produce high strength concrete. Compressive strength test 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. Then Flexural strength test is conducted on unreinforced concrete beam or slab to resist failure in bending. Then Split-tensile strength test one of the important properties of concrete is carried out. Increase in the partial replacement percent of seashells reduces the workability of concrete and moreover the density of concrete is found to decrease as the content of seashells was increased. In another study the author discuss about "Feasibility of Using Sea Shells Ash as Admixtures for Concrete." The main objective of this research is to produce pozzolanic admixtures from waste shells of periwinkle, oyster and snail. This study Produces of Pozzolanic Admixture by washing thoroughly to remove dirt and mud and then sun-dried for three days. Determination of Specific Gravity to determine in accordance with BS method. Then Determination of Consistency of Cement Pastes. After that Determination of Initial and Final Setting Times. And Production of the Mortar Cubes. Finally Compressive Strength Test (Benjamin et al. 2012).

Sasi et al. (2016) sought to replace the cement and crude raw part of lime and marine casing (10%, 20% and 30%) appropriately to increase the strength of concrete. But the strength is both combined with standard concrete only at 10% and 20% substitute of aggregate by marine shell. Power quietly reduces the replacement of 30% of the cortex. Therefore, we conclude that concrete and raw concrete replaced by lime and marine cover at 10% in concrete are suitable for construction. Moreover it reduces the assembly price by reducing the price of cement and rough assembly, it reduces in addition to environmental pollution due to lime and marine shell.

The authors explained about the strength of periwinkle casing concrete is ambitious established on the properties of the casings and assorted percentage replacement sand Concrete alongside 35.4% and 42.5% periwinkle casings inclusion can yet give the minimum 28-day cube strength benefits of 21 N/mm^2 and 15 N/mm^2 anticipated for concrete blends 1:2:4 and 1:3:6, suitably and Concrete possessing up to 50% periwinkle casings inclusion can yet be considered as normal heaviness concrete; and Savings of concerning 14.8% and 17.5% can be attained by adopting 35.4% and 42.5% periwinkle inclusion for 1:2:4 and 1:3:6 concrete blends, respectively. (Adewuyi and Adegoke, 2008)

III. Methodology

The experimental setup and methodology are discussed in this chapter. Cubes of standard size (150mm x 150mm x 150mm) were cast and tested to determine compressive strength after 28 days curing of the concrete using spent catalyst and seashells as the replacement of cement and coarse aggregate content in different proportion. The concrete mix designed by American concrete institute (ACI) (C30 Grade concrete). The steps of the research work is shown in Figure 3.1.

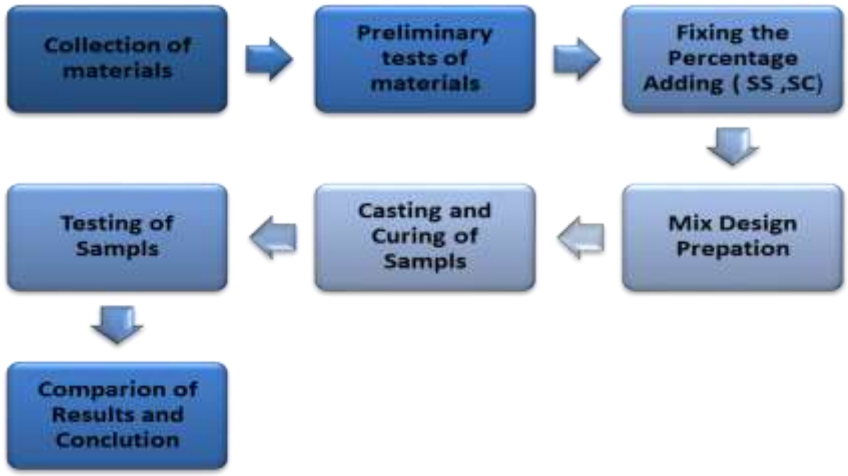

Figure 3.1 Steps of the research

3.1 Cement

There are many type of cement such as: Portland cement, Slag cement, Pozzolanic cements and High-alumina cement. The Portland cement is most widely used in Oman. In this study in the concrete mix Ordinary Portland Cement (OPC) was used (Figure 3.2).

Figure3. 2 Ordinary Portland cement

3.2 Aggregates

Aggregate is a rock like material. Used in many civil engineering and construction applications such as : Portland cement concrete, Asphalt concrete etc., It considerably improves the volume stability and durability of the concrete. The fine aggregate shall consist of natural sand or, subject to approval, other inert materials with similar characteristics, or combinations having hard, strong, durable particles. This project used fine aggregate with size ranging from 4.5 – 5mm(Figure 3.3). Due to its low thermal conductivity property fine aggregates are replaced with vermiculite and its compressive strength, tensile strength and flexural strength are tested (Divya, Rajalingam and Sunila, 2016).

Figure 3.3 Fine Aggregates

Coarse aggregate, is a kind of material which distributes widely. Rock can be divided into three types—sedimentary rock, igneous rock, and metamorphic rock. Different kinds of rocks have different impacts on concrete. In this study coarse aggregate was used with size ranging from 15-20mm (Figure 3.4)

Figure 3.4 Coarse Aggregates

3.3 Water :

Water is the important part in concrete and least expensive. It shall be clean without harmful impurities such as oil, alkali, acid, etc. In this study normal tap water from the laboratory is used for mixing the ingredients of concrete. In another research work the variation in compressive strength was observed with concrete mixed and cured with both fresh and sea water under different conditions for different ages of curing (Qingyong et al. 2018)

3.4 Spent Catalyst :

Spent catalyst is generated as a waste material around the world from the cracking of petroleum in oil refineries. The disposal of spent catalyst is of major concern to oil refineries. In Oman, there are two types of spent catalysts generated by refineries: Reduced Fluid Cracking Catalyst RFCC and spent alumina catalyst SAC. In this study RFCC was used (Figure 3.5).

Figure 3.5 Spent Catalyst

3.5 Seashells :

Seashells are partial remains of dead animals (Figure 3.6). Enormous quantities of shell waste are illegally abandoned on maritime coasts, or are incinerated in factories, which also cause pollution and destruction to the environment. Several studies have been carried out to investigate the feasibility of using shell waste in the field of civil engineering as a partial or total alternative to aggregates, sand or cement.

Figure 3.6 Seashells

3.6 Concrete Mixer:

A concrete mixer is a device that homogeneously combines cement, aggregates (coarse aggregate and fine aggregate), and water to form the concrete in required proportion.

3.7 Universal Testing Machine (UTM) :

A universal testing machine in general is used to determine the ultimate load carrying capacity of concrete specimens through which compressive strength is calculated. In one of the research works pull out test is conducted using a UTM of 100KN capacity for finding out the bond strength of concrete specimens. The failure patterns were observed on the specimen when subjected to pull out load (Dileep and Muhammed, 2016).

3.8 Preliminary tests for materials

To determine the physical properties of materials that are used for casting the concrete, the following preliminary tests have to be carried out in order to calculate the mix proportion.

3.8.1 Sieve Analysis Test

Sieve analysis is used to obtain the particle size distribution of a solid material by determining the amount of powder retained on a series of sieves with different sized apertures. A sample is added to the top of a nest of sieves arranged in decreasing size from top to bottom. As the sieves are vibrated, the sample is segregated based on the different sized sieves (Figure 3.7). A designated electromagnetic seive was connected to the electric mains and voltage was adjusted with the regulator to read 235 volts. The seive agitated as the voltage is varied and a stop watch is set to measure the time for a complete seiving (Ujam and Enebe, 2013).

Figure 3.7 Gyratory sieve shaker

3.8.2 Specific gravity test

Specific gravity of coarse aggregate is the ratio of mass of unit volume of coarse aggregate to the mas of same volume of water at specified temperature. It is a dimensionless value and consider the major factor to evaluate strength and quality of materials (Mohammed and Pandey, 2015). The weight of empty clean and dry pycnometer was determined and recorded. Then placed a dry soil sample in the pycnometer and recorded the weight. Water was added to fill the pycnometer, cleaned the surface of the pycnometer and recorded the weight. Then the pycnometer was emptied, cleaned and filled it with water and took the weight.

3.9 Mix design and Casting of Samples :

Designing the mix proportions is defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. For this study, the mix design was done by using ACI method of mix proportioning. The mix proportion is 1:1.94:2.34:0.5. The details of cube samples are shown below in Table 3.1.

Table 3.1 Details of cube samples

Concrete Mix	Replacement of spent catalyst (%)	Replacement of seashells(%)	No. of Cubes
M 1	0	0	3
M 2	10	5	3
M 3	15	5	3
M 4	20	5	3
M 5	10	10	3
M 6	15	10	3
M 7	20	10	3
M 8	10	15	3
M 9	15	15	3
M 10	20	15	3
Total Number of Samples			= 30

In this study 30 concrete cubes of size (150×150×150) cm are cast in Material Lab of Caledonian College of Engineering with different percentage of spent catalyst (5%,10% and 20%) and seashells (5%, 10% and15%), by replacing cement and coarse aggregate. The weight of different proportion of spent catalyst and seashells are measured using a standard weighing machine. The ingredients of concrete along with spent catalyst and seashells are mixed in the required proportion. After mixing concrete the cube moulds are cleaned and greased with oil. (Figure 3.8). The concrete is filled in 3 layers in the cube and compacted to reduce the voids (Figure 3.9).The concrete is finally smoothened using a trowel and are allowed to dry for a sufficient period and demoulded and kept ready for curing.


Figure 3.8 cleaning & greasing the cube moulds


Figure 3.9 Compaction of concrete in cube sample

3.10 Curing of cube samples in the water:

The samples are labelled with appropriate details such as date and percentage replacement to avoid confusion while testing. After removing the sample from cube mould it is immersed in water to cure for a period of 28 days (Figure 3.10 & Figure 3.11)


Figure 3.10 Cube Samples Cast

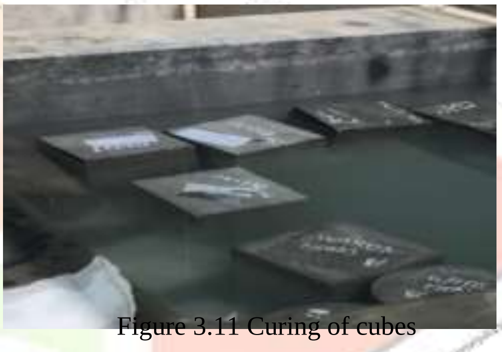
Figure 3.11 Curing of cubes

3.11 Compressive strength:

Compressive Strength Test has been carried out for ten groups consisting of reference mix, and concrete samples prepared with 5, 10 and 15 percent of spent catalyst and 10, 15 and 20 percent of seashells replacing cement and coarse aggregate. After curing the sample for 28 days it is removed and allowed to dry before carrying out the


Figure 3.12 Compression Test in Progress

compressive strength test. The above Figure 3.12 shows the Compressive test on cube sample.

IV. Result and Discussion

Various experiments were carried out to determine the properties of materials used in concrete. Preliminary tests such as specific gravity and sieve analysis were conducted in the college laboratory and the corresponding results were recorded for further use. The following Table 4.1 gives the specific gravity and fineness modulus values for both fine aggregates, coarse aggregates and sea shells.

Table 4.1 Properties of Aggregates

Type of Aggregate	Specific gravity	Fineness Modulus
Fine Aggregate	2.6	3.8
Coarse Aggregate	2.8	5.65
Sea shell	2.45	6.7

Compressive strength test results of all the samples with different mix designations are shown in Table 4.2 below:

Table 4.2 Compressive Strength Values of Various mixes

Mix Designation	Ultimate Load (KN)	Average Compressive Strength (N/mm^2)
M2	776.25	34.5
M3	827.25	36.8
M4	792	35.2
M5	805.5	35.7
M6	857.25	38.1
M7	840	37.3
M8	851.25	37.8
M9	902.25	40.1
M10	871.5	38.7

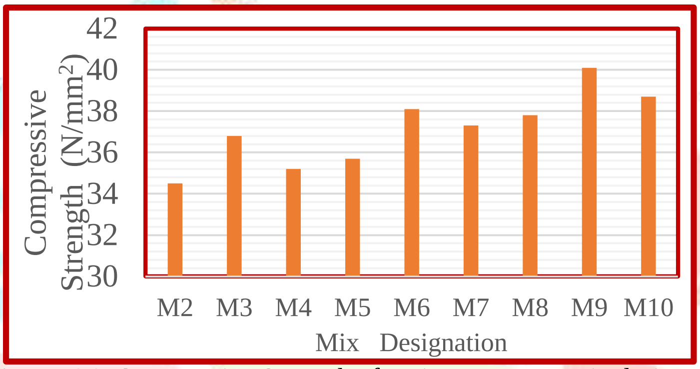

Figure 4.1 Compressive Strength of various concrete mix designations

Figure 4.1 above shows the compressive strength of various concrete mixes. It is evident that the maximum strength is achieved for mix M9 where spent catalyst replaces cement by 15 percent and sea shells replace coarse aggregates by 15 percent. Moreover the mix designations M3, M6 and M9 show that the compressive strength increases proportionately with increase of seashells in concrete partially at constant percentage replacement of cement with spent catalyst (15%). Mix M9 achieves a maximum strength of 40.1 N/mm^2 which is taken as the optimum percent replacement of sea shells and spent catalyst (15% & 15%) indicating improvement in the micro structure of cement paste which enhances the compressive strength of concrete to a greater extent. Table 4.3 below shows the different series along with their respective mix combinations.

Table 4.3 Combination of various mixes

Series	Mix Combination
A1	Control Mix & M2
A2	Control Mix & M3
A3	Control Mix & M4
A4	Control Mix & M5
A5	Control Mix & M6
A6	Control Mix & M7
A7	Control Mix & M8
A8	Control Mix & M9
A9	Control Mix & M10

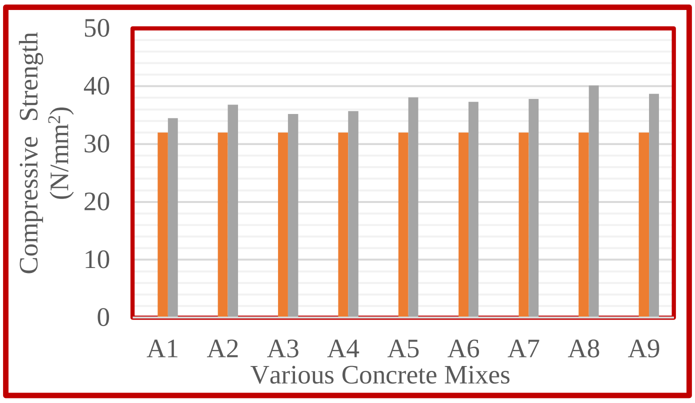

Figure 4.2 Compressive strength of combination of various mixes

The above Figure 4.2 shows the comparison of control mix with other mixes which have been replaced with seashells and spent catalyst in various proportions. From the figure series A8 shows that the compressive strength of mix M9 increases upto 25 percent when compared with the control mix value. Series A1 and A3 which compares the control mix with other mixes M2 and M4 shows a minor variation in the strength which may be neglected. It is observed that the replacement of cement with spent catalyst increases the compressive strength of the concrete mix considerably irrespective of the replacement percentage. The effect of seashell in strength improvement is negligible since the strength improvement is found to be in the range of 3 to 4 percent for the same percentage of spent catalyst for corresponding increase sea shell content.

V. Conclusion :

Based on the experimental values the following conclusions are drawn :

- Experiments conducted on various proportions of sea shell and spent catalyst reveal that the maximum strength is achieved at 15% partial replacement of cement by spent catalyst and 15% replacement of coarse aggregates by sea shell.
- The maximum compressive strength of concrete mix M9 after 28 days of curing is found to be 40.1N/mm^2 which is 25% higher than the conventional mix values.
- Compressive strength test results of all the mix proportions were found to be higher than the control mix values.
- The partial replacement of spent catalyst and seashells have a positive effect on the compressive strength of cube.
- The minimum compressive strength recorded is 34.5N/mm^2 which is 8% higher than the conventional mix values.
- The above results show that there is a considerable increase in compressive strength for every 5% increase of sea shell with a constant percentage of spent catalyst.
- The compressive strength of M3 mix replacing cement with spent catalyst (15%) and coarse aggregate with sea shells(5%) increases by 15% with reference to the control mix.
- The concrete mix replacing 15% of cement with spent catalyst and 10% of aggregates with sea shells shows 19% increase in strength when compared with conventional mix.
- For same percentage replacement of cement with spent catalyst and increase in seashells the strength improvement is very less when compared with the control mix values.

VI Acknowledgement

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