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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF CONCRETE WITH SUNFLOWER SEED HUSK ASH AS PARTIAL REPLACEMENT OF CEMENT

Balamuralikrishnan R[1]*, Sumaiya Marhoon Al-Dhahli[2] & Aravind N[3]
**[1, 2,3]Department of Built and Natural Environment, Caledonian Collage of Engineering, Sultanate of Oman*

***Corresponding Author:**
Email: bmk.gaya@gmail.com

Abstract:-
The present study depicts on mechanical properties of concrete with Sunflower Seed Husk Ash (SSHA) as partial replacement of cement. Concrete made with Ordinary Portland Cement is the most widely used material in all the countries. Hence the production of Ordinary Portland Cement is expensive and ecologically harmful. Cement industries releasing huge quantity of CO_2 which pollute the environment. Structural concrete can be produced using sunflower seed husk ash to meet strength and other requirements. In this project work, various percentages of SSHA added with concrete and the mechanical properties where studied. The effects of SSHA as partial replacement of cement on concrete properties was investigated. Concrete was produced by adding various amount of SSHA (2.5%, 5%, and 7.5%). From the literature review it has been noticed that the replacement of sunflower seed husk ash in concrete was very successful in reducing of unit weight, compressive strength, splitting tensile strength and freezing-thawing resistance. But water absorption rate is increased after 28 and 90 days. Based on experimental results its physical and mechanical properties show that concrete produced with sunflower seed husk ash has great potential as a low cost lightweight building material.

Keywords: - *Sunflower seed husk ash, Concrete production, and Mechanical properties*

1. INTRODUCTION

The production of Portland cement is not only costly and energy intensive, but it also produces large amounts of carbon emissions. Based on knowledge of the construction industry, cost of cement is high when compared with other concrete. Many of the countries have fast in technology always plan to recycle every waste may affect the environment or explore any material to reduce the cost of material have high cost like cement. Cement is the main component of any mix or building or structure. On that builder, engineers and architects always concerned for environment protection and resource conservation. Concrete can used in construction offshore, road pavement, multistory buildings, canal lining, tanks and dams. Research concrete looks for processes and material to obtain resistance and high initial, reduce cost of energy and cost of material, improve finish ability, tensile and pump ability improve compressive and density, reduce problems of delamination and dusting and resistance chemical. Concrete is a widely used material in the construction industry. Ordinary Portland Cement (OPC) is generally used as the primary binder of the concrete and in addition to that coarse aggregates, fine aggregates and water are also used in concrete construction. As the requirement for development in infrastructure increases the demand for the OPC concrete also increases. On the other hand, a major emphasis is given for the sustainable development in the construction industry. In order to comply with sustainable development concept, it is very important to minimize the negative environmental impacts of all construction works. The negative environmental impacts associated with the OPC production are much noticeable. During the manufacturing process of one ton of OPC, it releases a ton of Carbon Dioxide (CO_2) gas to the environment due to the process of calcination of limestone and combustion of fossil fuels. On the other hand, the amount of energy required for the manufacture of OPC is only second to the requirement of energy for manufacturing of steel and aluminum. In such a situation, these negative impacts will lead us to think of better alternatives and substitutes for OPC concrete. One of the alternatives which have been discussed as a substitute for OPC concrete is the Sunflower Seed Husk Ash (SSHA) concrete. Sunflower Seed is used for the preparation of sunflower oil and it is an eatable item. Cover of the seed is a waste material and in this project SSHA is added with concrete as partial replacement of concrete.

2. Literature Review

Authors C. B.Sisman & Erthan Gezer, 2013 discussed about the effects of Sunflower Seed Husk (SSH) as aggregate replacement material on concrete. Physical and mechanical properties were investigated. Author has concluded that the use of SSH as an aggregate replacement result in more water absorption [1]. Author S. Tangjuank, 2011 discussed about the thermal insulation and physical properties of particleboards from pineapple leaves. A particle board was created with waste pineapple leaves. Based on the results, authors have conclude that, for overall consideration of the thermal conductivity and physical properties of the pineapple leaves particleboard, the boards with particle: binder ratios of 1:3 with density of 210 kg/m3 are promising building materials for thermal insulation applications for energy saving [2]. Author Krishpersad Manohar, 2012 discussed on experimental investigation of building thermal insulation from agricultural by-products. The main objective is to study and investigate the physical properties and the variation of thermal conductivity with bulk density of oil palm fiber, sugarcane fiber and coconut fiber and their potential for use as building thermal insulation. The main result of this study test results indicates that, sugarcane fiber with the lowest solid fiber density of 686 kg/m3 exhibited the lowest apparent thermal conductivity of 0.04610 W/m.K and a trend of increase in solid fiber density of the material reflected an increase in the minimum of the fibrous batt [3].

Authors Dorota Dziurka & Radosław Mir ski, 2013 discussed about the lightweight boards from wood and rape straw particles. The main objective is to study and investigate the properties of lightweight (350–550 kg/m3) particleboards made by using wood or rape particles and with veneers applied to their surfaces. It was further observed that, the strength of the boards with the lowest density amounted to an average 38% of the strength of the highest density boards for both types of particles. Fit to be used in interior decoration, including furniture production [4]. Authors Singhadej Tangjuank & Supreya Kumfu, 2011 discussed about the particle boards from papyrus fibers as thermal insulation. The main objective was to study on the production and thermal property of thermal insulation produced from papyrus fiber using natural rubber latex as a binder [5]. Author Rafat Siddique., 2003 carried out an experimental investigation to evaluate the mechanical properties of concrete mixtures in which fine aggregate (sand) was partially replaced with Class F fly ash. Finally, to conclude that, the results of test indicate significant improvement in the strength properties of plain concrete by the inclusion of fly ash as partial replacement of fine aggregate (sand), and can be effectively used in structural concrete [6].

From this literature review, many researchers used rice husk ash and just one author has added sunflower seed with concrete. From the literature review, project gap is identified and in this project work sunflower seed husk ash was added with concrete and properties were studied.

3. Experimental Methodology

In this project, experimental works are conducted using various materials such as Ordinary Portland Cement (OPC), fine aggregate, coarse aggregate, Sunflower Seed Husk Ash (SSHA) and water. Concrete is added with 2.5%, 5%, 7.5% partial replacement of cement (by weight) SSHA. This project work was done by specifying the material and experimental set up.

3.1 Concrete Ingredients

Cement: In the present study, the type of cement used was Ordinary Portland Cement (OPC). Conforming to Omani Standard OS:7 and EN 197 -1, ASTM 150C - Type I. This is standard cement most commonly used when the special properties specified for any other type are not required. This is used for the general purpose. The chief chemical components of OPC are: Calcium, Silica, Alumina and Iron.

Fine Aggregate: Grinded stone with maximum size of 5 mm was used as fine aggregate. Fine aggregate used for concrete was free from salt and other chemicals. Specific gravity of fine aggregate was 2.68. 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.

Coarse Aggregate and water: The coarse aggregate was crushed granite stone available locally and has a maximum size of 20 mm according to code. Specific gravity of coarse aggregate was 2.64. The use of coarse and fine aggregates in concrete provides significant economic benefits for the final cost of concrete in place. They are the least expensive of the materials used in concrete. Normal water which is fit for drinking was used for mixing concrete and the w/c ratio was adopted 0.45.

Sunflower Seed Husk Ash (SSHA): Source of SSHA from grind in the grinding machine to become a powder then fire it in steel container by using diesel then sieve it in a sieve size 425µm as showing on Fig. 1 to become very fine ash. Fig. 2 show the procedure for fire SSH.

Fig. 1 Sunflower Seed Husk Ash (SSHA) Preparation

Fig. 2 Sieving Sunflower Seed Husk Ash using 425µm

3.2 Mix Design Concrete

In the beginning, numerous trial mixtures of SSHA concrete were manufactured, and test specimens in the form of 150x150x150 mm cubes and 150 mm diameter x 300 mm height of cylinder were made.
The mix design concrete used C 30 grade concrete to study the strength properties of concrete with 0%, 2.5%, 5% and 7.5% of SSHA as partial replacement of cement. The water cement ratio used is 0.45 for all the mixes. Depending on the mix design from concrete technology book, the weight of each material is put in Table 1. Mix ratio for C30 grade of concrete was done based on American Concrete Institute (ACI) code.

Table 1 Concrete Ingredients and Mix Proportions

SI No.	Cement (kg)		Sunflower Seed Husk Ash (kg)		Coarse Aggregate (kg)	Fine Aggregate (kg)	Water (lit)
	%	Kg	%	Kg			
1	100%	4.842	0%	0	13.128	11.891	2.1789
2	97.5%	4.721	2.5%	0.121	13.128	11.891	2.1789
3	95%	4.599	5%	0.242	13.128	11.891	2.1789
4	92.5%	4.479	7.5%	0.363	13.128	11.891	2.1789
Total		18.641		0.726	52.512	47.564	8.7156

Mix proportion as per mix design is 1:2.21:2.44 (cement: fine aggregate: coarse aggregate) with water cement ratio W/C of 0.45. Mix ratio by weight for C30 grade of concrete was calculated based on ACI code is shown in Table 2.

Table 2 Mix ratio by weight

Water	Cement	Fine aggregate	Coarse aggregate
177 kg/m^3	393.33 kg/m^3	871 kg/m^3	960 kg/m^3
0.45	1	2.21	2.44

3.3 Sieve Analysis of Aggregate

Sieve analysis test for fine aggregate was conducted in the laboratory to determine the grains size distribution and fineness modulus of fine fine aggregate as shown in Fig. 3.

Fig. 3 Sieve Analysis of Fine Aggregate

3.4 Casting

The mixing of SSHA with the cement, fine aggregate, coarse aggregate and water was done through a mixer machine. Casting and compacting the cube and cylinder were done manually. Size of the cube and cylinder used for casting were 150 x 150 x 150 mm and 150 mm diameter x 300 mm height respectively. For making the cube and cylinder, the molds were cleaned and oil was applied inside. The molds were then filled with the mixture and compacted manually in each layers. Fig. 4 shows the casting of cubes and cylinders after conducting slump test.

Fig. 4 Casting of Specimens 3.5 Curing of Specimens

Curing is very important process, thus concrete samples are cured in water before tested for required time. It is used to obtain strength of concrete and also to reduce the permeability. The concrete samples without curing will be very weak, less durable and produce more cracks. When it finish do the mixing, but the specimens 24 hours to dry then removed from the molds and kept it in a water tank as shows in Fig. 5. The curing period was 28 days.

Fig. 5 Curing for Cube specimens

3.6 Workability Tests (Slump Test)

The workability tests are performed on the fresh concrete specimens. Test of slump test to make sure of the effectiveness of fresh concrete. The device used for slump test consists of cone discharger with diameter of base 200 mm, diameter of top 100 mm and height of cone 300 mm. Cone base and the upper part of the balance each other in a right angle, are filled with concrete to three layers, each layers should compacted 25 times by a tamping rod. After that strike off the top surface of cone with a trowel or tamping rod so that the cone is filled to its top. After filled the cone with concrete excess concrete at the top portion was removed, ensuring its movement in vertical direction. Finally, when the settlement of concrete stops, subsidence of the concrete in millimeters was measured is known as the required slump of the concrete as shown in Fig. 6. The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as; collapse slump, shear slump and true slump. In a collapse slump, the concrete collapses completely, in a shear slump, the top portion of the concrete shears off and slips sideways and in a true slump the concrete simply subsides, keeping more or less to shape.

Fig. 6 Slump Test For Concrete

3.7 Compressive Strength Tests on Concrete cube

After 28 days, remove the specimen from the water and wait until dry and then specimen were transported to the lab for conducting the compressive strength test. Compressive strength test, mechanical test measuring the maximum amount of compressive load a material can be before fracturing. In this testing put the specimen in a good manner in 100 T Universal Testing machine (UTM) so the load will have applied in two faces of the specimen. Apply the load to the specimen gradually at the rate of 140kg/cm^2 minute. The test specimens of SSHA concrete are shown in Fig 7.

Compressive strength results are obtained through the following equation:

$$f_c = \frac{F}{A_c}$$

Where,

f_c : The compressive strength of cube.

F : The maximum load at the point of failure.

A_c: The cube cross-section

Fig. 7 Compressive Strength Tests for SSHA

3.8 Split Tensile Strength Test on Concrete cylinder

The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. After curing for 28 days of cylinder samples, the split tensile strength tests are done on hardened concrete specimens. The dimensions of the samples cylindrical are 150 mm diameter and 300 mm height. Use the UTM to apply the tests on cylinders also but in different way from cubes. The split tensile strength test on concrete cylinder are shown in Fig 8. The tensile strength results are obtained through the following equation:

$$f_{ct} = \frac{2P}{\pi \times L \times D}$$

Where,

f_{ct}: Tensile Strength of cylinder.

P: The maximum load at the point of failure.

L: Length of line in concrete with the specimen = 300 mm

D: Diameter of cylinder = 150 mm

Fig. 8 Split Tensile Strength Tests For SSHA

4. Results & Discussions

This section describes the result of the experimental work, the result of slump test, compressive strength and split tensile strength of SSHA concrete after curing 28 days.

4.1 Slump Test Results

Slump tests were conducted for normal mix and concrete mixed with SSHA and the results were plotted in Fig 9. The results show that slump test was true. In the first mix which is for normal concrete, the value of the mix is 12 mm but in the second mix which is for 2.5% of SSHA, the value of the slump test decreased to 10 mm. In the third mix which is replaced with 5% of SSHA, the value of the slump test increased to 11 mm and the last mix the value of the slump test decreased to 10 mm. The slump test results for all the mixes are shown in Table 3.

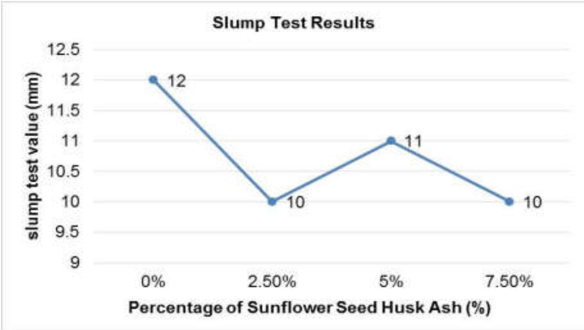

Fig. 9 Slump Test Results - Liner Chart

4.2 Compressive Strength Results

The compressive strength tests were conducted on concrete specimens after 28 days curing and the results are shown in Fig 10. The Universal Testing Machine (UTM) with capacity 100 T was used to apply load on the test cubes. In this study the mix ratio has been investigated for SSHA concrete with 2.5%, 5%, 7.5% partial replacement of cement. The compressive strength results of SSHA concrete in a different percentage are given in the Table 3.

Table 3 Slump, Compressive and Split Tensile Strength Results

SI No.	Type of mix	Average Compressive Strength (MPa)	Average Tensile Strength (MPa)	Slump Value (mm)
1	Normal	23.093	2.722	12
2	2.5% of SSHA	25.388	2.015	10
3	5% of SSHA	17.351	2.559	11
4	7.5% of SSHA	20.931	2.05	01

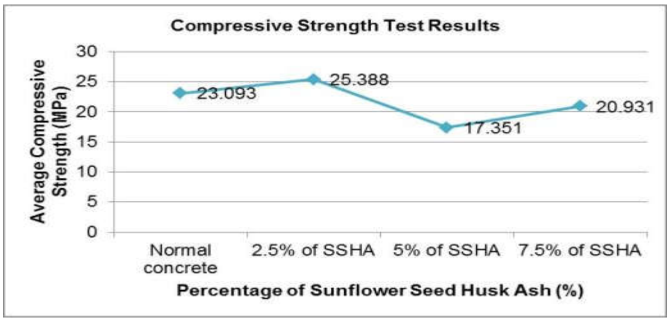

Fig. 10 Compressive Strength Test Results - Liner Chart

Based on the experimental study, 28 days compressive strength of concrete with 2.5% SSHA is more than the normal concrete. Also it clarifies that the compressive strength of the concrete decreased significantly at the SSHA percentage (2.5 to 5%) from 25.39 MPa to 17.35 MPa.

4.3 Split Tensile Strength Test Results

The split tensile strength tests were conducted on concrete specimens and the test results are shown in Fig 11. The Universal Testing Machine (UTM) with capacity 100 Ton was used to apply load on the test cylinders. In this study the mix ratio has been investigated for SSHA concrete with 2.5%, 5%, 7.5% partial replacement of cement.

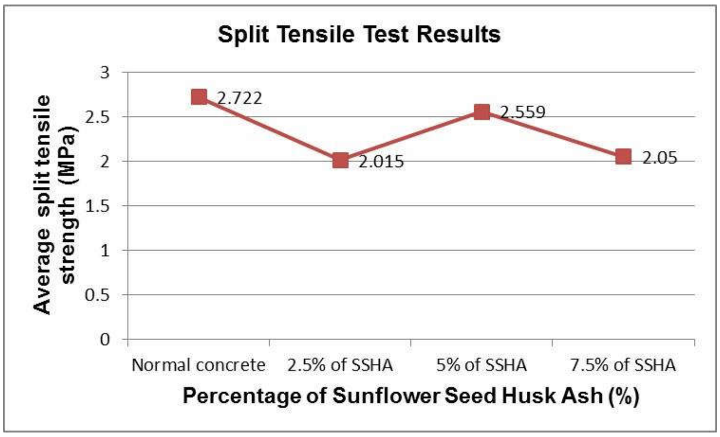

Fig. 11 Split Tensile Strength Test Results - Liner Chart

Also split tensile strength of concrete with 2.5% and 7.5% of SSHA are almost same. Based on the experimental study, 28 days split tensile strength of concrete with 5% SSHA is more than the split tensile strength of concrete with 2.5 and 7.5%.

5. Conclusions

Extensive experimental work was carried out in the laboratory to determine the effect of concrete with Sunflower Seed Husk Ash 2.5%, 5%, and 7.5% as replacement of cement and study the compressive strength and split tensile strength of concrete. The following conclusions are derived from the present study:

1. The compressive strength test and split tensile strength test for all samples was tested after 28 days curing.
2. Slump tests were conducted for normal mix and concrete mixed with SSHA and the results show that slump values vary between 10 and 12 mm.
3. The addition of SSHA to the concrete is effective for increase the compressive strength and decrease the split tensile strength in the range of 0%-2.5% of the replacement.
4. The addition of 2.5% of SSHA increases the compressive strength of concrete by 9.9 % when compared with the normal concrete and the benefit of that reduce high amount of cement, reduce the cost of concrete and have good compressive strength. On the other hand, compressive strength of concrete with 5% SSHA is reduced by 33% when compared with normal concrete. Similarly, compressive strength of concrete with 7.5% SSHA is reduced by 10.32% when compared with normal concrete.
5. Split tensile strength of concrete with 2.5%, 5% and 7.5% SSHA is decreased by 35%, 6.36% and 32.78% when compared with normal concrete respectively. Hence concrete with SSHA can be used for plain concrete preparation such as road works and pavement works.

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