Utilization of Sunflower Husk Ash in Concrete: A Sustainable Option

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***Abstract*—The present paper aims to review the utilization of sunflower husk ash in a sustainable manner. The concurrent study was carried out in order to find the suitability of agro waste ashes as an alternate substitute of cement in concrete. For the present project, six concrete mixes with cement were replaced with varied amounts of sunflower husk ash ranging from (2% to 12%) in M20 grade concrete. The optimum replacement level has been evaluated corresponding with 28 days of compressive strength of concrete. In order to study the effects of these additions, workability, density, and compressive strength properties test of concretes have been conducted. The result indicated that sunflower husk ash at 10% replacement level can be effectively used without compressive strength.**

Keywords: Sunflower Husk Ash,Agriculture Waste, Compressive Strength, Cement.

I. Introduction

In India, Sunflower or Surjmukhi is one of the short-duration crops of the Zaid season, introduced in 1969. . The scientific name is Helianthus is the combination of "Hellos" means Sun and "Anthons" which means the flower is originated in North America. In 2020-2021, According to United States Department of Agriculture, the production of sunflower was 50.04 million metric ton out of which 26.8 million metric ton was used for sunflower oil. This crop had gained popularity worldwide due to its good quality of oil, photo–insensitive property, different crop duration, high-energy husk, higher seed multiplication ratio, high-quality oil, and less water demand [1].

In India, the total production is 100 thousand metric tons, at some time the total consumption is 1.7 million metric tons, the remaining is imported. It has less production due to inaccessibility of good quality seeds, rain during the flowering period, damage by the birds, and less involvement of private companies [2].

According to the Oilseed Department of Agriculture, India (2017), its immature seed is used as feed for poultry, latex from leaves is a good source of rubber. The flower is an abundant source of nectar and pollen for honey. The fully grown seed contained 40 -53% of edible oil used in various types of cooking purposes. Its vegetable is light yellow contains a high percentage of linoleic acid which is good for heart patients. It has lecithin, tocopherols, and furfural, nutritious for birds also [3]. Agricultural waste ash is an end product, which is produced from those industries which use agricultural waste as fuel. Such types of ashes are not useful and most of the time are dumped near the water bodies to get moisture. Because of its lightweight, it can fly with wind from one place to another. The disposal of these ashes may become a major issue for the environment and society. The efficient use of these ashes can solve the environmental problem and may also affect the economic production of concrete.

Sunflower husk is the exterior cover of sunflower seeds. The husk is a waste generated during the sunflower seed and non – oil sunflower seeds de-husking process to get kernels. The husk contains 220 – 280 g per kg of the total weight of sunflower seeds.

Havrysh et al. (2020) suggested, sunflower husk is a good source of energy in oil mils. It is a biofuel of the combustion-based power plant, curtailed 200 – 300% CO_2, user can meet their demand and sell surplus electricity, get benefited with income up to 24.7 -65.7% [4]. Sunflower seed used in the incineration process and boiler and emits Carbon mono-oxide (18 – 23) mg/m^3, sulfur trioxide (2031 – 2105)mg/m^3, and Oxide of Nitrogen (240 – 293)mg/m^3 during the production of sunflower oil. Sunflower seed husk has 2500 – 2700 Kcal/Kg calorific values. [5,6]. In some countries, it has highest energy content is 15.4 MJ/Kg. because its carbon content is neutral, its energy generation could mitigate climate change [4].

The concurrent study was carried out in order to find the suitability of sunflower seed husk ash as an alternate substitute of cement in concrete. As the utilization of cement as building material becomes costly, it is a cheap material and can save water, energy and reduce the emission of greenhouse gases. These ashes can be easily available or produced and can be used in construction

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for material-efficient buildings. The utilization of ashes in a building may help to attain GRIHA credits by the green building council for the construction.

The aim of the present project was

a. To find a sustainablesolution of disposing of sunflower seed husk ash.
b. To evaluate the pozzolana property of suflower seed husk ash obtained and to be utilized as an alternate substitute of cement in concrete and
c. To obtain optimum mix proportion of ash in control mix concrete in order to enhance the overall properties of the concrete.

Table 1: Chemical Constituents of SSA

Constituents (%)	Sefias et al. (2012)	Tsado et al. (2014)
SiO_2	2.33	41.50
Al_2O_3	Less than 1	22.50
Fe_2O_3	Less than 1	9.05
CaO	13.69	5.18
MgO	8.84	1.04
SO_3	24.56	2.10
K_2O	36.64	0.95
Na_2O	Less than 1	0.81

IV. Material Used

A. Cement

Ordinary Portland Cement (OPC) 43 grade of Wonder trademark was used in this research. It confirms the properties as BIS 8112: 2013.

B. Fine Aggregates

Fine aggregates of particle size between 4.75 mm to 150 microns were used. River sand was utilized in this work and tests were carried out as per BIS – 2386. Tests show the quality of fine aggregates as per IS 838 – 1970.

C. Coarse Aggregates

For the present research work, single-sized 20mm coarse aggregates having specific gravity and moisture content of 2.703 and 1.377 respectively were used. A crushed stone was used in the present study and tests were conducted as per BIS – 2386. Testing shows the quality of coarse aggregates as per IS 838 – 1970.

D. Sunflower Husk Ash ***(SHA)***

Sunflowerhusk ash was collected from the Oil mils from Shahabad, Haryana where it was used as fuel. Ash was grounded in a ball milling machine and sieved through 90µ.

V. Mix Design of Concrete

Based on the physical properties of raw materials, the M20 grade control mix is designed as per IS code 10262:2009. For the Control mix concrete 348.36 Kg: 695.71Kg: 1190.32 Kg (Cement: Fine Aggregates: Coarse Aggregates) and 196Kg water were obtained. S-2.0, S-4, S-6, S-8, S-10 and S-12.0, designed concrete were manufactured by replacing cement with SHA by mass at different replacement levels (2.0%, 4%, 6%, 8%,10% and 12%). Concrete was prepared by thoroughly mixing raw material at room temperature. The prepared concretes were cast in cube mould of size (150 x 150 x 150) mm and submerged in potable water after 24 hours of casting. At the curing age of 3, 7, 14, and 28 days, the compressive strength of determined by applying the load at the rate of 140kN/mm^2/min. till the cube collapse under the universal testing machine.

VI. Result and Discussion

The physical and chemical parameters of cement are shown in table 1.Result indicated that cement conforms to IS Standards.Chemical analysis of sunflower husk ash is given in table 2. Chemical analysis of ashes showed that a combination of oxides (SiO_2 + Al_2O_3 + Fe_2O_3) is less than 50% for SSA. The sum of oxides was found to be less than 50% therefore it was also classified as non – pozzolanic material.The specific gravity of SSA was found to be 1.171.

A. Workabılıty of SSA Concrete

"Slump test was used to measure the workability of fresh concrete depending upon the grading of the particles, shape of the aggregates, water-cement ratio and the consistency and finesse of cement". By considering the entire influence factors constant, the only mixed proportion of the ashes varies from 0% to 12.0% at a constant interval of 2.0% of modified concrete were prepared. The slump values of individual ash-modified concrete are presented in fig.1.

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Table 2: Physical and Chemical Characteristics of OPC 43 Cement

S.No	Test	Results Obtained	Required as per BIS 8112: 2013
1	Fineness (m^2/Kg)	227	225 (Min.)
2	Soundness (mm)	8	10 (Max.)
3	Setting time (min): (a) Initial (b) Final	 190 345	 30 (Min.) 600 (Max.)
4	Comp. str.(MPa) (a) 3 days (b) 7 days (c) 28 days	 24 33.2 44.2	 23 (Min.) 33 (Min.) 58 (Max)
5	Specific gravity	3.18	-----
6	Consistency	32	----
7	$\frac{\text{Cao -0.7 } SO_3}{2.8\ SiO_2 + 1.2\ Al_2O_3 + 0.65\ Fe_2O_3}$	$\frac{57.51 - 0.71\ (3.4)}{2.8\ (19.75)+1.2\ (5.1)+0.65\ (3.94)}$ = 0.86	0.66 – 1.02
8	Alumina/ Iron Oxide	5.1/3.94 = 1.29	0.66 (Min)
9	Magnesia	4.01	6.0 (Max)
10	SO_3	3.40	3.5 (Max.)
11	LOI	4.15	5 (Max)
12	K_2O	0.61	----
13.	Na_2O	0.35	0.6(Max)

Table 3: Chemical Analysis of Sunflower Seed HuskAsh

SiO_2	Al_2O_3	Cao	Fe_2O_3)	MgO	Na_2O	K_2O	SO_3
17.2	**4.3**	**2.91**	**0.75**	**2.47**	**0.21**	**6.64**	**1.04**

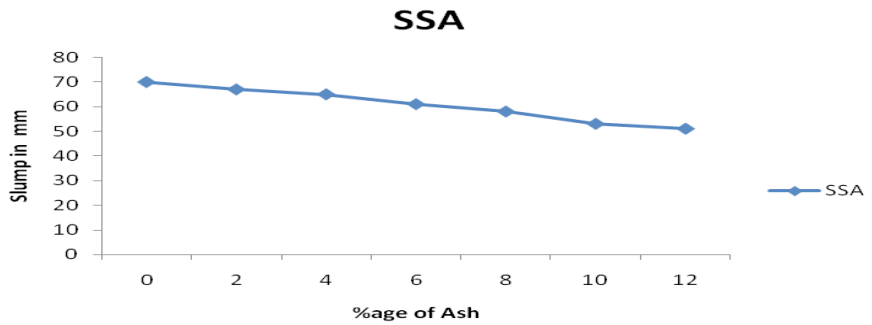

Fig. 1: Slump values (mm) of SSA

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The result presented in Fig. 1 shows that the slump value of control mix concrete was found to be 70mm at 0.55 of water/cement ratio. It was found to be less than as per standard concrete. This was happened due to the high ambient temperature between 38°C to 40°C during the preparation of concrete mixes, which cause the evaporation of a large amount of mixed water during hydration. Slump values of SSA concrete decresed from 70 mm to 51 mm with increasing amount of ash in cocnrete. Similar results were experienced by Burge et al. (1996) when they cast moulds at various ambient temperatures and found that slump decreased with an increase in temperature [7].

The density of the hardened cubes was carried out on 28 days water cured 150 mm x 150 mm x 150mm sized cubes cast for both types of modified concrete. The density of the modified concrete is presented in fig 2.

From the results, it was found that control mix concrete has a maximum density of 2440 kg/m^2 and it decreases from 2360 kg/m^2 to 2335 kg/m^2 with increment in the amount of ash. This happened due to the low specific gravity of the SSA such as 2.76 than 3.15 of cement and consumption of SiO_2 during hydrationreaction.

The results of comp. str. of cubes of mix proportion with 0% to 12.0% substitution of cement with sunflower husk ash (SSA) are given in fig 3. From the results, it was found that the comp. str. of the SSA concrete at 12% replacement was less than the control mix concrete. Compressive strength further decrease with increasing amount of SSA. Similar test results were found by Sensale et al (2012) in their study on sunflower seed husk as cementitious materials in a mortar [8].

SunflowerHusk Ash replaced cement up to 10% by mass shows compressive strength value equivalent to target mean strength values of concrete . It may be due to a large number of alkalies and sulfate ions formed ettringite which provides strength to the concrete. Therefore sunflower husk ash acted as chemical admixture [9,10].

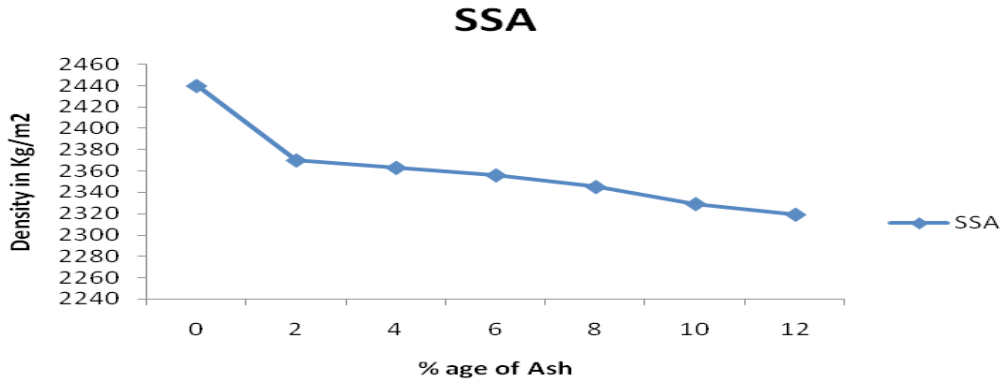

Fig. 2: The Density of SSA Concrete

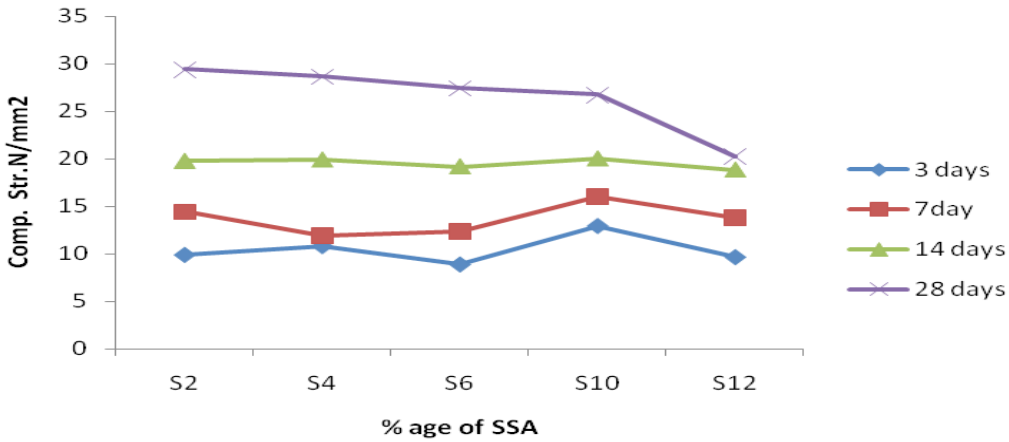

Fig. 3: Compressive Strength (N/mm^2) of SSA cubes

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II. Conclusion

The review of the research papers indicates the applications of sunflower seedhusk ash in concrete. Disposal of this waste in open landfills can cause environmental pollution, leads to degrading the quality of air, water, and soil. The optimum replacement value is 10% for sunflower seed husk ashand beyond this level of ash, strengths start reducing. From the results, it is concluded that the use of sunflowerhusk ash as chemical admixture, is an option for sustainable concrete.

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