# AN EXPERIMENTAL STUDY OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY ALGAL WEED ASH

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***Abstract :- Solid concrete is the world's most crucial and important construction material, made up of fine and coarse aggregates, cement, and water. Cement manufacturers must generate huge amounts of cement to fulfill growing infrastructure demands. Because cement is so expensive, other building materials have become more expensive. Cement production contributes to global warming by releasing large amounts of energy and CO2, thus encourage researchers to develop novel cementing components that are economical. Today, conserving natural resources means saving money and coming up with innovative and efficient alternatives. For decades, waste materials from industrial and domestic sources are used to partially replace various components in concrete while keeping costs low and pollution-free. Algal weed ash partially replaces cement very well. Algal weed ash concrete is made by optimizing the additive addition to M30 grade concrete. This research sought to find a way to partially replace cement using algal weed ash. A M30 concrete mix with a 0.5 water-to-cement ratio was used here. 2% ash was determined to be the best cement alternative. Optimum concrete proportions surpassed standard concrete specimens mechanically and durably. Using these findings, we can minimize pollution and construction expenses while increasing concrete strength.***

***Keywords:- Green concrete, algal weed ash, Building material, waste, pollution-free, circular economy***

## 1. INTRODUCTION

The term "concretus" is derived from a Latin word for condensed or compacted, as well as the excellent passive participle of "concrescere," which originated from the prefix "con-" (together) and the verb "crescere" (to grow) (Irwin, 2018). Each year, over ten billion tons of concrete are generated, making it one of the most consumable commodities on the entire globe, second only to water. A particularly strong and malleable building material, concrete is primarily composed of cement, gravel, and aggregates (e.g., sand or broken stones) combined with slurry in an acceptable mix proportion (Watts, 2019). The paste, which is a combination of water and Portland cement, covers the surface of the coarse and fine aggregates during a reaction known as hydration, solidifying, and increasing durability to produce the stone structure. Similar to the bulk referred to as concrete, even expert structural engineers occasionally use the terms "cement" and "concrete" interchangeably, while in actuality, cement is an ingredient of concrete (Juenger et al., 2011).

Figure-1 Dal Lake defaced by algal weed (Weeds, Red Algal Bloom Deface Dal, 2016)

As a fact, little study has been undertaken on a novel substance that may be used in place of cement that has a negligible impact on the environment. Algal weed ash is a novel cement alternative that is readily visible and excisable from lakes and ponds. Algal weed ash can be used for cement, which would affect numerous mechanical properties of concrete. Durability is the quality of concrete that makes it resistant to chemical assault and pollution from the environment. Cement is substituted with 1%, 2%, and 3% algal weed ash to determine the optimal partial replacement of cement with algal weed ash, as well as the water absorption and strength properties. The findings were compared to those obtained using ordinary M30 concrete and those obtained using partly replaced algal weed ash concrete.

## 2. OBJECTIVES OF STUDY

1. To determine the mechanical and durability qualities of concrete containing Algal weed ash.
2. To compare the efficacy of Algal weed-infused concrete to that of conventional cement concrete.
3. To determine the optimal proportion of algal weed ash in concrete for maximum.

Experimental Work
Materials used
Cement

During this investigation, the OPC 53-grade cement was used for the experimental procedure according to IS 12269-2013. The tests conducted for determining the properties of cement by IS 12269-2013 are given in Table-1.

Table- 1 Test result of cement OPC 53 grades

| S.No. | Details of Experiments Performed | Results |
|---|---|---|
| 1. | Standard consistency | 30% |
| 2. | Setting time<br>i. Initial setting time.<br>ii. Final setting time. | <br>42<br>292 |
| 3. | Specific gravity | 3.15 |
| 4. | Soundness (Le-Chatelier test) | 1mm expansion |
| 5. | Overall compressive strength in Mpa.<br>i. 3 Days strength<br>ii. 7 days strength<br>iii. 28 days strength | <br>35<br>47.4<br>64.1 |

Fine aggregates

The fine aggregate was collected from the Jhelum River at Amirakadal, Srinagar. The fine aggregates were sieved using a 4.75mm sieve with a fineness modulus of 2.758 and a specific gravity of 2.59, respectively. The particle size distribution of fine aggregates is shown in Table- 2 Sand conformed to IS 383-2016 grading zone II.

Sieve analysis of fine aggregate

Sample taken = 1000gm.

Table- 2 Sieve analysis of fine aggregate

| S.No. | Is-sieve size(mm). | Wt. retained (g). | % Weight of sample retained. | Cumulative %age retained. | %Age weight passing. |
|---|---|---|---|---|---|
| 1. | 4.75 | 0 | 0 | 0 | 100 |
| 2. | 2.36 | 0 | 0 | 0 | 100 |
| 3. | 1.18 | 3 | 0.3 | 0.3 | 99.7 |
| 4. | 600µ | 37 | 3.7 | 4 | 96.3 |
| 5. | 300 µ | 708 | 70.8 | 74.8 | 29.2 |
| 6. | 150 µ | 219 | 21.9 | 96.7 | 78.1 |
| 7. | PAN | 33 | 3.3 | 100 | 96.7 |
| | | | | ? = 275.8 | |

Fines modulus of fine aggregate = 2.758.

Zone = zone-2 (medium sand).

Coarse aggregate

We employed hard broken granite stones that passed through 20 mm and 12.5 mm sieves but were kept on 12.5 mm and 4.75 mm sieves, respectively, with a fineness modulus of 5.22 and 3.449 and a specific gravity of 2.70. The particle size distribution of the coarse aggregate is shown in Table- 3

Figure 2 Sieve analysis of coarse aggregate

Sieve analysis of 20mm coarse aggregates:

Sample taken = 5000gm.

Table- 3 Sieve analysis of 20mm coarse aggregate

| S.No. | Is-sieve size (mm). | Wt. retained (g). | % Weight of sample retained. | Cumulative %age retained. | %Age weight passing. |
|---|---|---|---|---|---|
| 1. | 30 | 0 | 0 | 0 | 100 |
| 2. | 25 | 0 | 0 | 0 | 100 |
| 3. | 20 | 681 | 13.62 | 13.62 | 86.38 |
| 4. | 16 | 1398.5 | 27.97 | 41.59 | 58.41 |
| 5. | 12.5 | 1748 | 34.96 | 76.55 | 23.45 |
| 6. | 10 | 779 | 15.58 | 92.13 | 7.87 |
| 7. | 6.3 | 336 | 6.72 | 98.85 | 1.15 |
| 8. | 4.75 | 23.5 | 0.47 | 99.32 | 0.68 |
| 9. | Pan | 34 | 0.68 | 100 | 0 |
| | | | | ? = 52206 | |

Fines modulus = 5.22

Sieve analysis of 10mm coarse aggregate

Table-4 Sieve analysis of 10mm coarse aggregates

Sample taken = 5000gm

| S.No. | Is-sieve size(mm) | Wt. retained (g) | % Weight of sample retained | Cumulative %age retained | %Age weight passing |
|---|---|---|---|---|---|
| 1. | 30 | 0 | 0 | 0 | 100 |
| 2. | 25 | 0 | 0 | 0 | 100 |
| 3. | 20 | 0 | 0 | 0 | 100 |
| 4. | 16 | 244.5 | 4.89 | 4.89 | 95.11 |
| 5. | 12.5 | 989 | 19.78 | 24.67 | 75.33 |
| 6. | 10 | 1045.5 | 20.91 | 45.58 | 54.42 |
| 7. | 6.3 | 1685 | 33.7 | 79.28 | 20.72 |
| 8. | 4.75 | 560 | 11.2 | 90.48 | 9.52 |
| 9. | Pan | 476 | 9.52 | 100 | 0 |
| | | | | ? = 344.9 | |

Fines modulus of 10mm coarse aggregate = 3.449

Collection of raw material (Algal weed)

**Collection of raw material (Algal weed)**

Figure 3 Collected algal weed

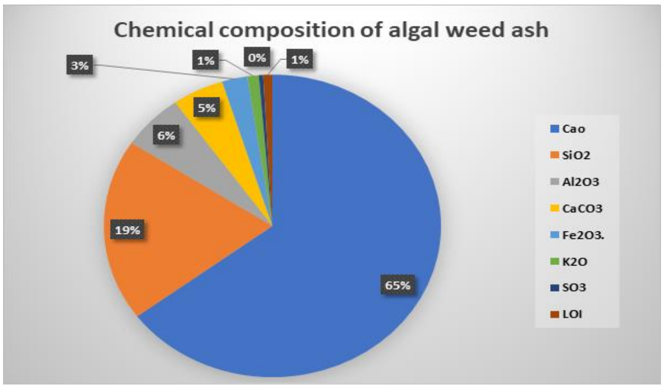
Figure 4 Manual collection of weeds

Fresh algal weed was harvested from Srinagar's Dal Lake. The collected algal weed was washed with fresh water to eliminate contaminants such as dirt.

Table-5 Chemical composition of algal weed ash

| Chemical composition | Percentage |
|---|---|
| Cao | 62.21 |
| SiO2 | 18.62 |
| Al2O3 | 5.72 |
| CaCO3 | 4.76 |
| Fe2O3. | 2.35 |
| K2O | 1.06 |
| SO3 | 0.4 |
| LOI | 0.84 |




Graph-1 Chemical composition of algal weed ash

Water

Drinkable clean water available in the laboratory and fulfilling the requirements of IS 456-2000 was used for casting and curing concrete specimens.

Admixture

Chemical admixture such as Auramix-200 was used as the admixture in the mix.

Mix Proportion

The IS code 10262-2009 was followed for the preparation of plain concrete (M30 grade). The composition for the mixed proportion of native (control) concrete is

Cement: Algal weed ash: Fine aggregate: Coarse aggregate is 1: 2.31: 3.90 with a w/c ratio of 0.5.

Mixing and Casting

The coarse and fine particles were originally combined in the concrete mixer for two minutes. The cement was added to the mixer and mixed dry for approximately 2.5 minutes. After that, water with an admixture (Auramix-200) was added, and mixing proceeded for an additional 6 minutes. Finally, the mixes were supplemented with the necessary amount of algal weed ash and stirred for 5 minutes to ensure equal dispersion.

Figure-5 Concrete Mixer

Figure-6 Steel Molds with concrete

Figure-7 Table Viberator

Figure-8 Molded concrete cubes

Freshly mixed concrete was poured into stiff steel molds that had been cleaned and oiled with oil on the sides; the molds were crushed using a table vibrator so that minimum air voids are left inside the concrete cubes. After 24 hours, the specimens were demolded and cured in a water tank until they reached the required age for testing.

Testing Methodology

The specimens were subjected to compressive strength test and water absorption test at ages 3, 7, and 28 days. Average values were computed. The test findings were compared to those of a control concrete specimen that did not include algal weed ash.

Strength Tests on Hardened Concrete

Compressive Strength Test

Compressive strength testing was performed in line with the IS 516-1999 standard. Compressive strength tests were performed on cube specimens (150 mm x 150 mm x 150 mm) with varying amounts of algal weed ash. After three, seven, and twenty-eight days of curing, the specimens were evaluated in a compression testing machine with a capacity of 2000 kN and a testing rate of 14 N/mm2/min. The setup of the compressive strength test is depicted in the figure.

Figure-7 Table Viberator

Figure-8 Molded concrete cubes

Water Absorption Test

The water absorption test was performed on cube specimens 150mm x 150mm x 150mm following the ASTM C 642-97 protocol. At 28 days into the curing period, the specimens were removed from the curing tank and dried in a hot air oven at a temperature of 100 to 110 °C for a minimum of 24 hours before the test.

Figure-11 Water Tank

Figure-12 Hot Air Oven

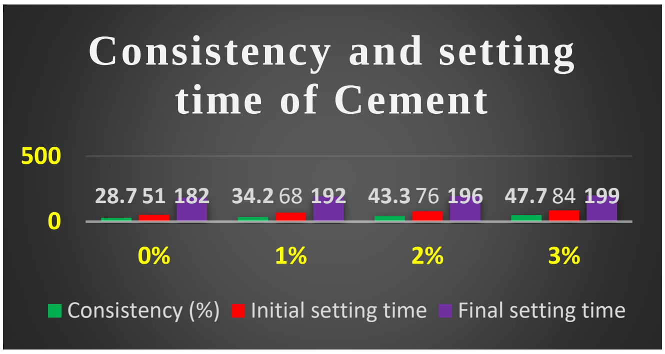
After allowing the specimens to cool in the air, their weights were calculated. The drying procedure was repeated until the difference in weights between consecutive weights approached zero. After cooling to room temperature, the dried specimens were weighed (Wdry). The specimens were then submerged in water. After 30 minutes of immersion, the specimens were weighed (Wint). The 30-minute water absorption rate was used as the beginning water absorption rate. After 120 hours, the specimens were submerged in water. The specimens were removed from the water after 120 hours and weighed. It was referred to as the saturated mass (Wsat). Equations 1 and 2 are used to compute the initial and saturation water absorption of the concrete specimen using these weight values.

Initial water absorption (%) = [(Winit – Wdry)/ Wdry] x 100 (1)
Saturated Water absorption (%) = [(Wsat – Wdry)/ Wdry] x 100 (2)

Were, Wdry = Weight of oven-dried specimen in g
Wsat = Weight of saturated specimen in g
Winit = Weight of specimen after 30 minutes in g.

## 3. RESULTS AND DISCUSSION

A minimum of three specimens were evaluated for each experiment mix of partial cement replacement with algal weed ash, i.e., 1%, 2%, and 3%. All tests were done by the standards, as necessary. Compressive strengths were determined using 150 x 150 x 150 mm cube specimens by IS: 516. Three distinct age groups were examined: 3, 7, and 28 days. Compressive strength data for twenty mixtures at three different age levels are provided in the table 4.3.1. The given strengths are averages of three specimens.

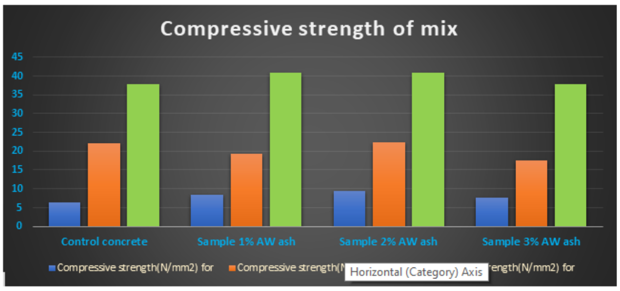



Graph-2 Represents Consistency and Setting Time of Cement

Mechanical properties
Compressive strength test
The compressive strength results at the different ages such as 3, 7, and 28 days are presented in Table-15 The development of compressive strength with different ages are shown in the Figure
Compressive strength of mix
Concrete mix 1: 2.31: 3.90 (by weight)
W/c ratio 0.5

Table-6 Result of Compressive Strength at 3, 7 and 28 days

| Percentage replacement of cement by AWA (%) | Compressive strength(N/mm2) for different Treatment in Days | | |
|---|---|---|---|
| | 3 days | 7 days | 28 days |
| Control concrete | 6.37 | 22.2 | 37.77 |
| 1% ash | 8.41 | 19.27 | 40.84 |
| 2% ash | 9.43 | 22.4 | 40.88 |
| 3% ash | 7.61 | 17.44 | 37.79 |

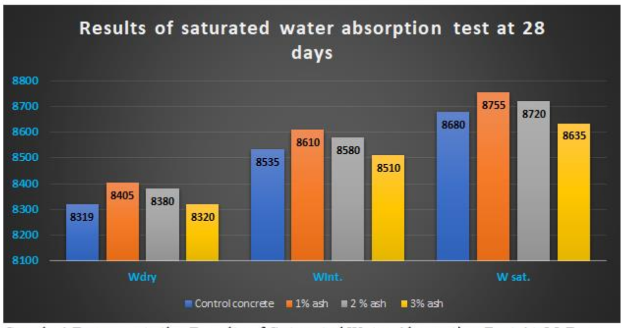



Graph-3 Represents Compressive Strengths of Sample Specimens

Durability Studies
Water Absorption Test
The outcome of the water absorption test after 28 days is shown in Table-16. For the main water absorption capacity of the concrete specimens, the recommendations of the concrete society CEB (1989) were considered. According to (Concrete, 1989), if the first water absorption value is less than 3%, the concrete is considered to be of high quality. According to these recommendations, all of the concrete mixes evaluated in this study are of high quality. The test findings indicate that the algal weed ash concrete absorbs less water initially than control concrete.

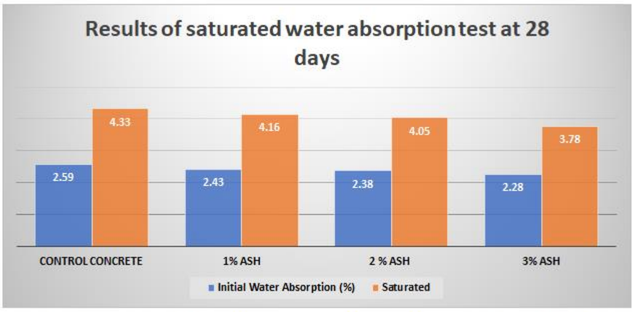
Table-7 Results of Saturated Water Absorption Test At 28 Days

| No. | Mix Designation | Wdry (gm) | Wint. (gm) | Wsat (gm) | Initial Water Absorption (%) | Saturated Water Absorption (%) | Concrete Quality As Per CEB (1989) |
|---|---|---|---|---|---|---|---|
| 1. | Control concrete | 8319 | 8535 | 8680 | 2.59 | 4.33 | Good |
| 2. | 1% ash | 8405 | 8610 | 8755 | 2.43 | 4.16 | Good |
| 3. | 2 % ash | 8380 | 8580 | 8720 | 2.38 | 4.05 | Good |
| 4. | 3% ash | 8320 | 8510 | 8635 | 2.28 | 3.78 | Good |




Graph-4 Represents the Results of Saturated Water Absorption Test At 28 Days




Graph-5 Represents the Results of Saturated Water Absorption Test at 28 Days

Water absorption is 4.33 percent in the control mix at 28. When compared to control concrete, algal weed absorbed less saturated water. According to (Boban et al., 2017), concrete cubes using 0.5 percent WHF (water hyacinth fiber) as a fine aggregate substitute achieved comparably high compressive strength values. According to their observations, using WHF in concrete results in decreased water absorption, increased durability, and increased compressive strength at elevated temperatures.

## 4. DISCUSSION

Compressive Strength Outcomes

According to test results, Algal weed ash aggregate concrete with different proportions 0:100, 21:79, and 69:31 demonstrated improvements in compressive strength above control concrete at 3 days, 7 days, and 28 days, respectively.

Comparing algal weed ash concrete to control concrete, the compressive strength gain was 32.025 percent, 48.03 percent, and 19.46 percent for concrete mixes containing 1%, 2%, and 3% volume fractions of algal weed ash, respectively. Compressive strength increases by 48.03 percent in the 2% ash mix and by 32.025 percent in the 1% ash mix.

Thus, the optimal ratio of cement to algal weed ash is 2%, or 42:58, which results in a high compressive strength at all ages when compared to control concrete. These findings corroborate earlier research by (Ramasubramani et al., 2016). For M25 grade concrete, sea brown algae were utilized as additional material at 2%, 5%, 8%, and 10% of the cement content with set water to cement ratio (W/C = 0.5) to generate M25 grade concrete, and tensile strength tests were performed at 3, 7, and 14 days. Their findings indicated that the addition of marine algae altered the hardness qualities of concrete. However, when additional marine algae are added, the compressive strength tends to diminish. Deflection characteristics tests revealed that optimal mixed concrete beams had a greater ultimate load-bearing capability than standard concrete beams. Thus, the study found that adding 8% marine algae to concrete boosted its strength qualities, but when raised to 10%, the capabilities began to deteriorate. (S. Dinesh, 2017), on the other hand, examined concrete cubes after seven days of curing and eventually compared the workability and strength performance of ash-mixed concrete to ordinary concrete. According to their experimental findings, the optimal proportion of water hyacinth ash to cement was 10% for M30 grade concrete.

## 5. CONCLUSION

The findings of the tests on the fresh concrete and the hardened concrete were discussed in this chapter. It is also described how the workability test result of the hardened concrete qualities, such as compressive strength, influenced the final product. Based on the findings of the inquiry, the best feasible mixing combinations are discovered and discussed. When it comes to compressive strength, the mix with 2 percent algal weed ash had the most positive synergistic impact out of all the combinations tested. When algal weed ash was increased in fresh concrete from 0% to 3%, the setting time of cement also increased from 182minutes to 277minutes. The results of the durability tests, such as water absorption, are also mentioned. Various algal ash blends are addressed in terms of their durability qualities when mixed with concrete mixtures. The outcomes of the tests conducted during this experimental inquiry were compared to those found in the existing literature studies. The hybrid mixtures with 2 percent ash fared better in the durability tests than all of the other hybrid mixtures combined. Because of this, it is determined that the optimal hybrid mixture is a 2 percent ash blend, which has superior strength and durability attributes.

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