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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH COCONUT SHELL ASH AND SILICA FUME IN CONCRETE

Dr.R.Umamaheswari[1], M.Vigneshkumar[2]

[1]*Assistant professor, Department of Civil Engineering, University college of Engineering, Dindigul.*
[2]*P.G Student, M.E.(Structural Engineering),Anna university regional campus, Madurai*

Abstract - *There are lots of environmental impacts of cement on our ecology. Cement industry creating environmental problem by emission of CO_2 during manufacturing of cement. Today researchers are more focusing towards the environment issue globally. This experimental study investigates the strength performance of concrete using Ordinary Portland Cement and Coconut Shell Ash and Silica Fume. Initially, coconut shell ash and silica fume samples were collected and its properties were investigated. Normal consistency and setting time of the pastes containing ordinary Portland cement and coconut shell ash at 5%, 10% & 15% and silica fume at 5% & 10% replacement were investigated. Compressive strength, flexural strength, split tensile strength, durability test and density of M_{50} concrete containing ordinary Portland cement with coconut shell ash at 5%, 10% & 15% and silica fume at 5% & 10% replacements were also investigated at water cement ratio 0.35. The mix design used for making the concrete specimens was based on previous research work from literature*

Key Words: *coconut shell ash, silica fume, Compressive Strength, Split Tensile, Flexural Strength, Durability strength.*

1. INTRODUCTION

It is generally known that, the fundamental requirement for making concrete structures is to produce good quality concrete. Good quality concrete is produced by carefully mixing cement, water, and fine and coarse aggregate and combining admixtures as needed to obtain the optimum product in quality and economy for any use Good concrete, whether plain, reinforced or prestressed, should be strong enough to carry super imposed loads during its anticipated life. Other essential properties include impermeability, durability, minimum amount of shrinkage and cracking.

The growing concern of resource depletion and global pollution has challenged many researchers to seek and develop new materials relying on renewable resources. These include the use of by-products and waste materials for building construction. A considerable amount of **coconut shells and silica fume** remain in the environment as waste, so utilization of these materials for construction will be an important step to improve sustainability and eco-friendly construction. The concrete even releases huge amount ofco_2 into atmosphere and to reduce that we have partially replaced with coconut shell ash and silica fume.

2.LITERATURE REVIEW

Utsev, J. T.,& Taku, J. K. (2012) Have conducted the Concrete cubes were produced using various replacement levels of 0, 10, 15, 20, 25 and 30 percent of OPC with CSA. A total of 54 cubes were produced and cured by immersing them in water for 7, 14 and 28 days respectively. Properties such as compressive strength, density, setting times and pozzolanic activity index were determined. The results showed that the densities of concrete cubes for 10 -15% replacement was above 2400Kg/m3 and the compressive strength increased from 12.45N/mm2 at 7days to 31.78N/mm2 at 28 days curing thus meeting the requirement for use in both heavy weight and light weight concreting. Thus, 10 -15% replacement of OPC with CSA is recommended for both heavy weight and light weight concrete production.

Shaik.Aliimran Tippu,& Vr.Prasanth Kumar(2015) have conducted The undertaking paper goes for examining split tensile strength and compressive strength characteristics with complete replacement of coarse combination with coconut shell to supply light-weight concrete and to exchange cement by exploitation silica fume as admixtures with completely different percentages (0%, 10%, 15%, 20%, 25% and 30%) to urge smart strength like standard concrete. Concrete 63 cubes and 63 cylinders are casted with mix proportion (1:1.47:0.65) and their mechanical properties are determined and compared with standard concrete.

3. MATERIALS USED

3.1 Cement

Ordinary Portland Cement (OPC) of 43 grade confirming to IS:1489 - 1991 (Part II) are used in this study. The tests are carried out according to IS codes to find out the physical properties and are tabulated in Table 1

Table 1 Properties of Ordinary Portland cement

S.No	Properties	Value
1	Grade	43Mpa
2	Specific gravity	3.15
3	Initial setting time	30mins
4	Final setting time	10hrs

3.2. Fine Aggregate

Table 2 Properties of fine aggregate

Properties	Value
Specific gravity	2.72
Fineness modules	3.2 (Zone III)
Size	Passing through 2.36mm sieve

3.3 Coarse Aggregate

Table 3 Properties of Coarse Aggregates

Properties	Value
Specific gravity	2.64
Size	Passing through 12.5mm and retained in 10mm sieve
Fineness modulus	7.17

3.4 Water

Water plays an important role in the formation of concrete as it participates in chemical reaction with cement. Due to the presence of water the gel is form which helps in increase of strength of concrete.

3.5 COCONUT SHELL ASH

Global production of coconut is 51 billion nuts from an area of 12 million hectares. South East Asia is regarded as the origin of coconut.

- Although the lignin content is higher.
- The cellulose content is lower.
- Chemical composition to hard wood.
- Good durability characteristics.
- High toughness & abrasion resistant properties.

The coconut shell was sun dried for forty eight hours to remove moisture from it. It was then subjected to uncontrolled combustion using open air burning for three hours and allowed to cool for about 12hours. The burnt ash was collected and sieved through a BS sieve (75 microns). The resulting ash, which has the required fineness, was collected for use.

Literature study shows 10% replacement is optimum.

Specific gravity of coconut shell ash = 1.33

Fig. 1 Coconut shell ash

Table 4 Chemical Composition of CSA

Chemical composition	%
Carbon (C) (%)	49.80
Silica fume (SiO2) (%)	64.20
Alumina (Al_2O_3) (%)	6.51
Iron (Fe_2O_3) (%)	6.98
Calcium (CaO) (%)	10.56
Sulphuric Anhydride (SO_3) (%)	1.05
Glucose (%)	0.1
Fructose (%)	0.1
Sucrose (%)	0.1

3.6 SILICA FUME

- In this investigation, Silica fume was sourced from Astrra Chemicals, Chennai, Tamil Nadu was used in this investigation Specific gravity of silica fume was 2.2.
- Silica fume commonly used mineral admixtures which replace the cement by its fineness property.
- Silica fume is general passes through 75 microns and which is finer than cement.
- Silica fume is a byproduct in the carbo thermic reduction of high-purity quartz with carbonaceous materials like coal, coke, wood-chips, in electric arc

furnaces in the production of silicon and ferrosilicon alloys.

- Silica fume is added to Portland cement concrete to improve its properties, in
- particular its compressive strength, bond strength, and abrasion resistance.

Fig 2. Silica fume

Table 5 Chemical Composition of Silica Fume

Chemical composition	%
SiO_2	94.3
Al_2O_3	0.09
Fe_2O_3	0.10
Cao	0.30
Mgo	0.43
K_20	0.83

4. EXPERIMENTAL PROGRAMME

M_{50} grade of concrete was considered in this present study. Mix design was carried out according to the recommendation of IS 10262-(2009). Cement was partially replaced with coconut shell ash from 5% to 15% and silica fume from 5% to 10% an interval of 5% by weight of cement and strength properties of the concrete will be studied. Properties of cement replaced with silica fume and coconut shell ash concrete in fresh state such as workability and in hardened state such as density, strength tests are carried out.

4.1 MIX DESIGN

Table:6 Percentage quantities and the mix ratio of various percentages of CSA & SF

Cement (%)	(CSA+ SF)%	RATIO : C : CSA : SF : FA : CA
100	(0+0)%	1 : 0 : 0 : 1.12 : 1.92
90	(5+5)%	1 : 0.055 : 0.055 : 1.21 : 2.08
85	(5+10)%	1 : 0.055 : 0.055 : 1.21 : 2.08
85	(10+5)%	1 : 0.117 : 0.058 : 1.26 : 2.16
80	(10+10)%	1 : 0.125 : 0.125 : 1.33 : 2.28
80	(15+5)%	1 : 0.187 : 0.062 : 1.31 : 2.25
75	(15+10)%	1 : 0.200 : 0.130 : 1.39 : 2.38

4.2. RESULTS AND DISCUSSION

4.2.1 COMPRESSIVE STRENGTH

Compressive Strength test was carried out on cube specimen of dimensions 150 x 150x150 mm. The compressive test specimen were cured and tested for 7 days,14 days and 28 days in compressive testing machine.

Table 7 Tabulation for compressive strength

MIX	COMPRESSIVE STRENGTH (N/mm^2)		
% OF CSA & SF	7 days	14 days	28 days
0%	34.50	40.10	53.11
(5+5)%	37.20	42.20	53.30
(5+10)%	40.10	45.30	54.40
(10+5)%	43.50	47.70	57.60
(10+10)%	45.30	48.20	59.60
(15+5)%	38.30	43.20	55.60
(15+10)%	37.70	41.10	53.30

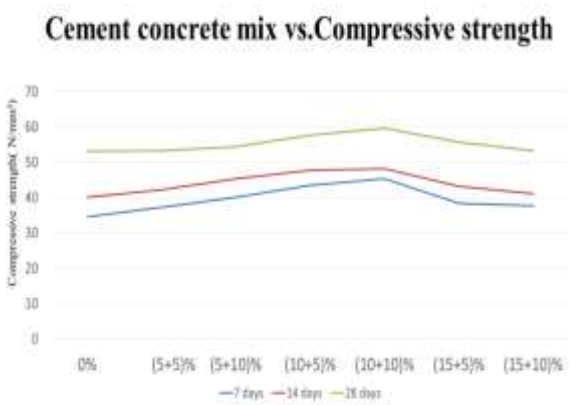

Chart 1 Percentage of (CSA+SF)% vs compressive strength

Finally the specimen attains the strength in the range of 45.30 N/mm^2 for 7days, 48.20 N/mm^2 for 14 days and 59.60 N/mm^2 for 28 days. The test results, obtained of cube specimens indicated that at (10% CSA+10% SF) compressive strength increases but further increase in CSA percentage, decreases the strength of concrete cubes. The compressive strength increases by 30% for concrete mix containing (10+10)% of CSA and SF than the control mix.

4.2.2 FLEXURAL STRENGTH

Flexural test was carried out on prism size of specimen 100x100x500mm. The flexural test specimen were cured and tested for 7 days,14 days and 28 days in testing machine.

Table 8 tabulation for flexural strength

MIX	FLEXURAL STRENGTH (N/mm2)		
% OF CSA & SF	7 DAYS	14 DAYS	28 DAYS
0%	5.7	7.1	8
(5+5)%	6.6	7.7	9.7
(5+10)%	7.1	8.9	10.5
(10+5)%	8.8	10.1	11.4
(10+10)%	10.2	11.5	12.2
(15+5)%	9.1	9.9	11.1
(15+10)%	8.5	9.5	10.1

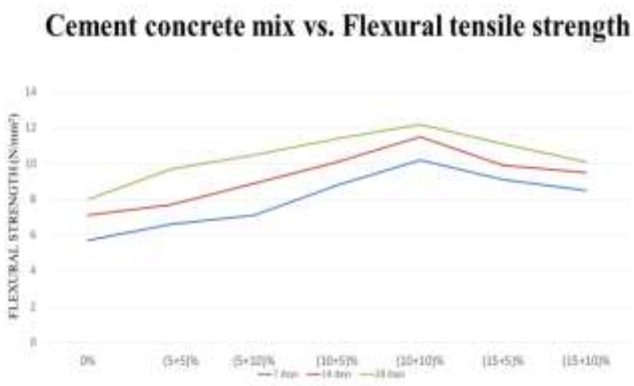

Chart 2 Percentage of (CSA+SF)% vs flexural strength

Finally the specimen attains the strength in the range of 10.2 N/mm^2 for 7 days, 11.5 N/mm^2 for 14 days and 12.2 N/mm^2 for 28 days. The test results, obtained of prism specimens indicated that at (10% CSA+10% SF) flexural strength increases but further increase in CSA percentage, decreases the strength of concrete prisms. The flexural strength increases by 52.5% for concrete mix containing (10+10)% of CSA and SF than the control mix.

4.2.3 TENSILE STRENGTH

Tensile Strength test was carried out on cylinder specimen of dimensions 300 mm height, dia 150 mm. The tensile test specimen were cured and tested for 7 days,14 days and 28 days in compressive testing machine.

Table 9 Tabulation for tensile strength

MIX	TENSILE STRENGTH (N/mm^2)		
% OF CSA & SF	7 DAYS	14 DAYS	28 DAYS
0%	2.32	2.52	2.77
(5+5)%	2.77	2.99	3.65
(5+10)%	3.01	3.68	4.2
(10+5)%	3.12	3.88	4.4
(10+10)%	3.74	3.97	5.1
(15+5)%	3.1	3.57	4.4
(15+10)%	2.9	3.47	4.3

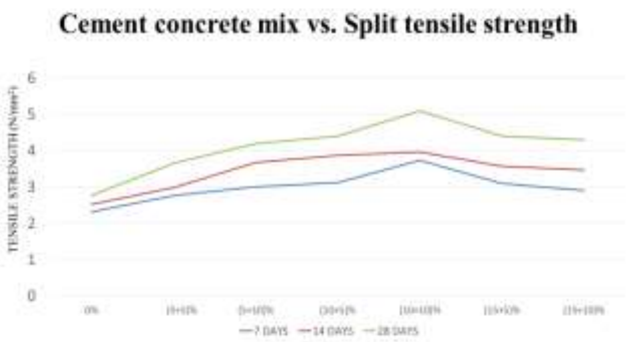

Chart 3 Percentage of (CSA+SF)% vs tensile strength

Finally the specimen attains the strength in the range of 3.74 N/mm^2 for 7days, 3.97 N/mm^2 for 14 days and 5.10 N/mm^2 for 28 days. The test results, obtained of cube specimens indicated that at (10% CSA+10% SF) tensile strength increases but further increase in CSA percentage, decreases the strength of concrete cylinders. The tensile strength increases by 60% for concrete mix containing (10+10)% of CSA and SF than the control mix.

4.2.4 DURABILITY TEST

For acid attack the test concrete cube of size 150x150x150 are prepared for various percentages of thermocol addition. The specimen are cast and cured in mould for 24 hours, after 24 hours the entire specimen are demoulded and kept in curing tank for 7 days. After 7 days specimens are immersed in 5% HCL solution for 30 days. The pH value was maintained at 0.35.

Table 10 Tabulation for compressive strength of normal and acid curing concrete

MIX	COMPRESSIVE STRENGTH FOR 28 DAYS (N/mm^2)	
% OF CSA & SF	NORMAL WATER CURING	ACID CURING
0%	53.11	47.35
(5+5)%	53.3	45.3
(5+10)%	54.4	44.9
(10+5)%	57.6	48.57
(10+10)%	59.6	51.35
(15+5)%	55.6	46.43
(15+10)%	53.3	45.2

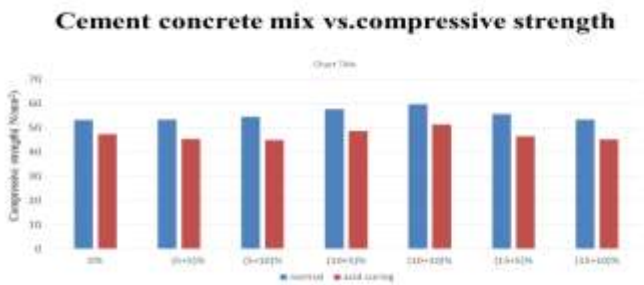

Chart 4 Percentage of (CSA+SF)% vs compressive strength of normal & acid curing concrete

Finally the acid curing specimen attains the strength in the range of 51.35 N/mm^2 for 28 days. The test results, obtained of cube specimens indicated that at (10% CSA+10% SF) compressive strength increases but further increase in CSA percentage, decreases the strength of concrete cubes. The compressive strength increases by 8% for acid curing concrete mix containing (10+10)% of CSA and SF than the control mix.

5. CONCLUSION

- It is observed that compressive strength, split tensile strength and flexural strength are on higher side for 15% of CSA & 10% SF as compared to other concrete mixes.
- The optimum value for (CSA + SF) in cement concrete was found to be (10% + 10%).
- Finally this project concludes the making CSA & SF concrete, the test results show that the partially replacing CSA & SF resulted in a significant increase in concrete compressive strength compared with the conventional concrete.

6. REFERENCES

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