Examining Concrete Properties using Coconut Fiber Ash and Fly Ash as Partial Replacement for Cement

Peresia Blapoh Wungko[#1], K.Bindumathi[*2]

[#1] *Post Graduate Student, Department Of Civil Engineering, Sri Venkateswara College Of Engineering & Technology*** (AUTONOMOUS) R.V.S Nagar, Chittoor, Andhra Pradesh, India*

*#2 Assistant Professor, Department of civil Engineering, Sri Venkateswara college of Engineering & Technology*** (AUTONOMOUS) R. V. S Nagar, Chittoor, Andhra Pradesh, India*

Abstract - *Concrete is a composition of cement, coarse aggregate, fine aggregate and water which makes it a composite material. Fly ash which is a waste material is used as a supplementary cementitious material in the production of Portland cement and when added to concrete, it gives good workability, greater strength, decreases permeability and increases durability. Coconut fiber is an agricultural waste which can be burned into ash and when added to concrete as a partial replacement of cement, it has great potentials.*

The aim of this project work is to investigate concrete properties using coconut fiber ash and fly ash as partial replacement for cement in regards to the compressive strength which is investigated for 3,7, 28,56 and 90 days. Since concrete is weak in tension due to its brittle nature, it is necessary to conduct the split tensile strength test. Durability test which is an important factor to prove a concrete ability to resist weather action, chemical attack, and abrasion while maintaining its desired engineering properties is also investigated in this project work.

In this project work, mix proportion of M40 grade of concrete was used for 8 mixes in accordance with IS 456: 2000 and IS 10262: 2009. These mixes were an inclusion of separate mixes of conventional concrete as well as different percentages of coconut fiber ash and fly ash as a partial replacement for cement of which the various results obtained for the partial mixes strength will be compared to the strength of the conventional concrete. The addition of coconut fiber ash ranges from 20% to 40 % and fly ash ranges from 10% to 25%.

Nowadays, regular materials used for construction are very expensive and unaffordable by many lower income people, thereby unaware of the usages of some waste materials which can be partially replaced as construction material and at the same time reducing cost. Sensitization is to be created in the usage of those waste materials such as coconut *fiber ash as a construction material which is also an objective of this project work.*

Keywords— *concrete, coconut fiber ash, workability, durability, fly ash, compressive strength, split tensile strength.*

I. INTRODUCTION

Without objection, concrete is one of the most widely used modern building materials. Concrete is an "artificial stone" obtained by mixing cement, sand, and aggregates with water. Fresh concrete can be configured into almost any shape, giving it an inherent advantage over other materials. The precursor to concrete was invented in about 1300 BC when Middle Eastern builders found that when they coated the outsides of their pounded-clay fortresses and home walls with a thin, damp coating of burned limestone, it reacted chemically with gases in the air to form a hard, protective surface. This wasn't an actual concrete, but it was the beginning of the evolution of cement. The coconut tree is commonly called the tree of life because it can be used for multi-purposes. The production of coconut plays a major role in the life activities ranging from the production of food to others things such as fabrics, ropes, etc. Due to the high cost of materials used in construction such as cement, has given rise to finding an alternative binder which can be used as a partial replacement for concrete, thereby reducing the cost by reducing the quantities of cement for construction. Coconut fiber ash is one of those many alternative binder replaced partially with cement. These fibers are obtained from the coconut which are available in larger quantities mainly in tropical regions like Asia, Africa and America. The inclusion of other substances to partially replace cement is not a strange procedure. This is something that has been done over the years, thereby incorporating many different types of natural waste and other substances which has been used for experimental process and later practicalized based on substantial reports. In this exploration, coconut fiber ash which is also known as coir fiber ash and fly ash are used to enhance the performance of concrete. The used of these materials does not only enhance the strength of concrete but also improves the environment and

reduced pollution by getting rid of them for construction purposes. However, research in the understanding of coconut fiber ash and application for construction purposes as partial replacements are still being carried out all over the world with the aim of using these waste materials to help ease the economic and financial tensions in both rural and urban areas in regards to the high rise of cement cost.

II. MATERIALS AND METHODS.

A. Coconut fiber ash

Coconut fiber, also known as coir, comes from the inmost husk of coconuts. According to the University of Florida Extension, coconuts are the most extensively grown products in the world which contribute significantly to the economy of many tropical areas. The short, tough fibers can have varieties of uses from clothing, shelters etc. Unlike man-made fibers, coconut is a renewable

There are two types of coconut fibers, brown fiber which is an extraction made from matured coconuts and white fibers which are extracted from immature coconuts. Brown fibers are thick, high strength and have high scrapping resistance. White fibers appears smooth and fine, but also weaker. Both the brown and white coir are consisting of fibers ranging in length from 4-12 in (10-30 cm). Those fibers that approximately 8 in (20 cm) long are called bristle fiber. Fibers that are shorter in length which are also finer in texture, are called mattress fiber. Coconut producing countries especially India, Tanzania, Kenya, Bangladesh, Burma, Thailand, Sri Lanka, Nigeria, Ghana, etc, have led to the development of coir industries.

Coir gives a natural, non-toxic replacement for asbestos in the production of cement fiberboard. The fiber-reinforced concrete is strong, flexible and may be less expensive to produce than other reinforcement methods such as wire mesh or rebar (Ben Davis of Georgia Tech University). Coconut fiber ash is the byproduct after the coir or fiber has been thoroughly burnt.

B. Fly ash

Concrete producers can now use a group of materials called “fly ash” to improve the quality and durability of their products. Fly ash improves concrete’s workability, pumpability, cohesiveness, finish, ultimate strength, and durability as well as solves many problems experienced with concrete today–and all for less cost. Fly ash, however, must be used with care. Without adequate knowledge of its use and taking proper precautions, problems can result in mixing, setting time, strength development, and durability

III.PREPARATION OF SPECIMEN

Preparation of coconut fiber ash and other materials were done for specimens of the below replacements percentages.

A. Casting of specimens

The casting of specimen were done in sequence as convention concrete, coconut fiber ash was replaced by 20% , 25%, 30% and 40%. The percentages of fly ash were 10%, 20% 25% and 30%. The both replacement percentages were done by weight of cement

The specimen were tested for 3, 7, 28, 56 and 90 days compressive strength, 28 days spilt tensile strength and 28 days acid attack test strength

IV. RESULTS AND DISCUSSION

A. COMPRESSIVE STRENGTH

Cubes and cylinders were placed in the compressive strength testing machine and load were applied until failure.

V. TABLE I
COMPRESSIVE STRENGTH OF CUBES

S. No	**% of Cfa**	**Coconut Fiber ash Replacement Only (N/mm^2)**				
		3 Days	7 Days	28 Days	56 Days	90 days
1	0	16.81	27.44	42.14	50.93	56.01
2	20	11.30	14.43	29.00	34.41	38.21
3	30	9.05	12.18	26.41	30.90	34.44
4	40	7.31	10.01	21.24	26.34	30.92

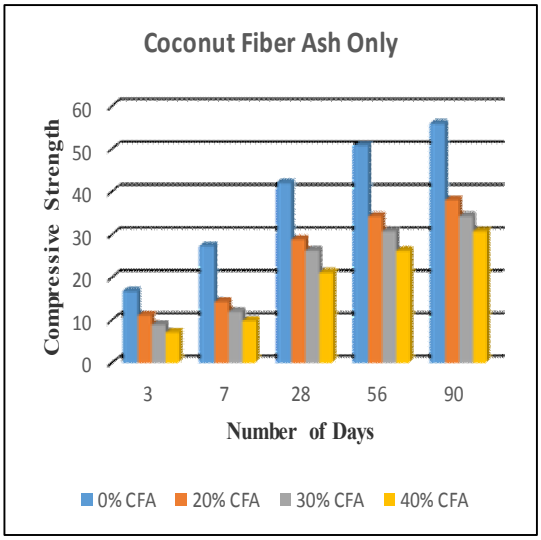

Fig. 1 A 3D cluster chart showing compressive strength of coconut fiber ash replacements only versus number of days.

VI. TABLE III
COMPRESSIVE STRENGTH OF CYLINDERS

S. No	% of CFA	Coconut Fiber Ash Replacement Only (N/mm^2)
		28 days
1	0	36.20
2	20	23.94
3	30	21.65
4	40	17.26

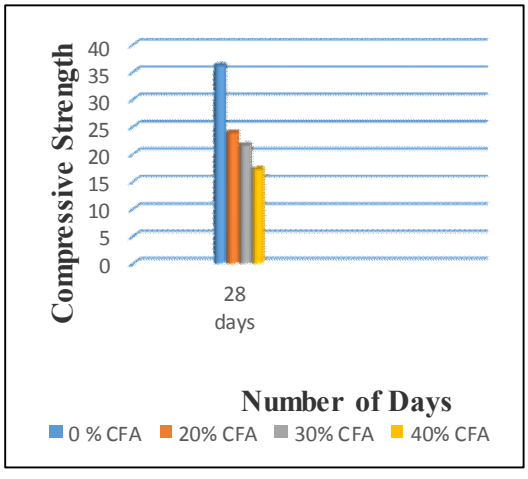

Fig.2 A 3D cluster chart showing 28 days compressive strength of cylinders with coconut fiber ash replacements only versus number of days.

VII. TABLE III
COMPRESSIVE STRENGTH OF CUBES WITH BOTH CFA AND FLY ASH REPLACEMENTS

S. No	% of CfA	Coconut Fiber ash Replacement and Fly Ash (N/mm^2)				
		3 Days	7 Days	28 Days	56 Days	90 days
1	20% CfA & 10% F-A	18.37	19.98	30.96	36.83	41.91
2	20% CfA &20 % F-A	11.28	13.86	20.09	27.90	32.12
3	25% CfA & 25% F-A	9.06	11.36	21.16	25.11	28.34
4	40% CfA & 30% F-A	7.02	9.81	18.07	22.11	24.47

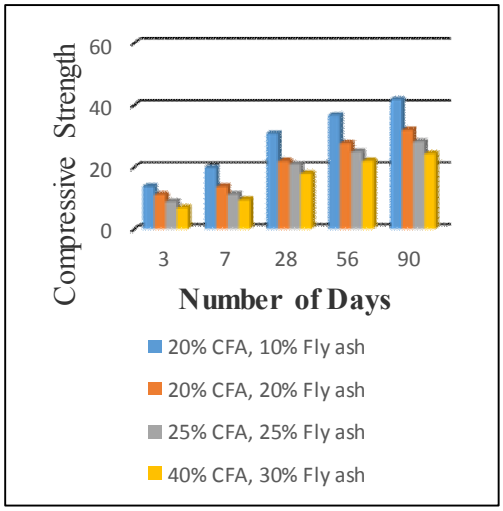

Fig.3 A 3D cluster chart showing compressive strength of cubes with coconut fiber ash and fly ash replacements.

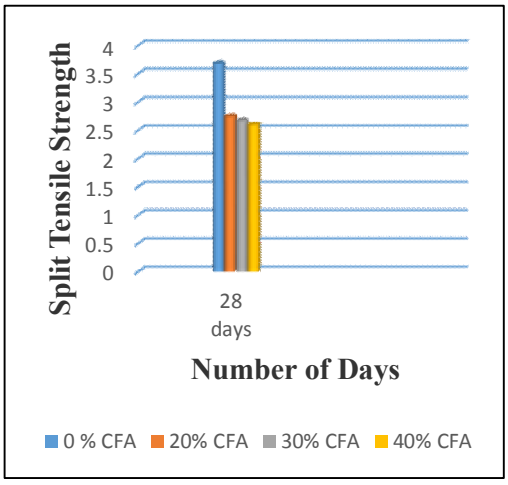

Fig.4 A 3D cluster chart showing 28 days split tensile strength of cylinders with only coconut fiber ash replacements.

B. SPLIT TENSILE STRENGTH

Cylinders were positioned in the universal testing machine and load was applied on it. At the point if failure the load was recorded. The results are displayed below.

VIII. TABLE IV
SPLIT TENSILE STRENGTH OF CYLINDERS WITH ONLY COCONUT FIBER ASH REPLACEMENT

S. No	% of coconut fiber ash	Coconut fiber ash replacement only (N/mm^2)
1		28 days
2	0	3.69
3	20	2.75
4	30	2.61

IX.TABLE IV
SPLIT TENSILE STRENGTH OF CYLINDERS WITH COCONUT FIBER ASH AND FLY ASH REPLACEMENT

S. No	% of coconut fiber ash and fly ash	Coconut fiber ash and fly ash replacement (N/mm^2)
		28 days
1	20% CFA and 10% fly ash	2.89
2	20% CFA and 20% fly ash	1.99
3	25% CFA and 25% fly ash	1.84
4	40% CFA and 30% fly ash	1.27

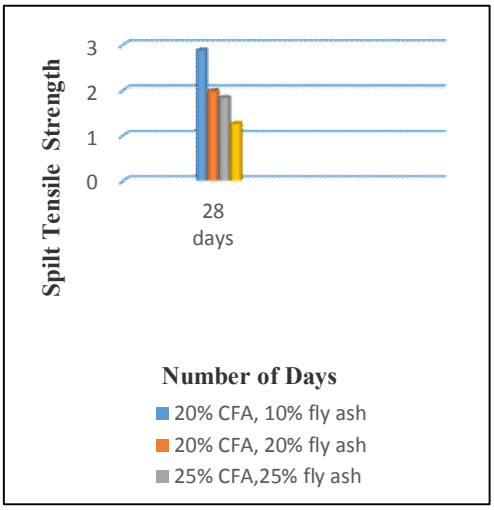

Fig.5 A 3D cluster chart showing 28 days split tensile strength of cylinders with coconut fiber ash and fly ash replacements.

C. ALKALINE ATTACK TEST

For the determination of the resistance of cubes with different percentages replacements, the cubes were immersed in a solution of Sodium Hydroxide (NaOH) and allow to cure for 28 days. The cubes were later dried and tested for compressive strength. The results are shown in the table below.

X. TABLE V

COMPRESSIVE STRENGTH OF CUBES SUBJECTED TO ALKALINE ATTACK

S. No	% Replacement of CFA and Fly ash	Compressive strength (N/mm^2) for 28 days
1	0%	39.87
2	20% CFA	26.81
3	30% CFA	23.71
4	40% CFA	16.62
5	20% CFA, 10% fly ash	28.86
6	20% CFA, 20% fly ash	20.12
7	25% CFA, 25% fly ash	19.01
8	40% CFA, 30% fly ash	15.29

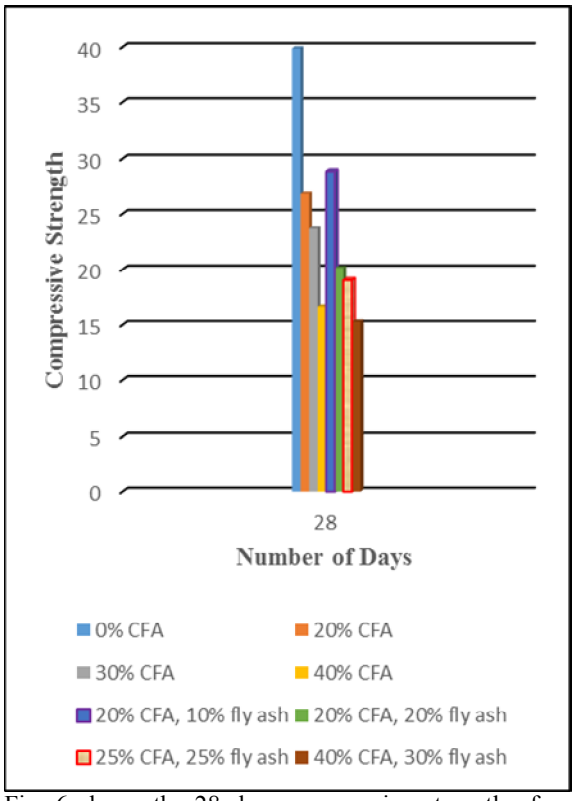

Fig. 6 shows the 28 days compressive strength of cubes under alkaline attack.

XI. CONCLUSIONS

This investigation has proven that the addition of coconut fiber ash and fly ash by a certain percentage can yield positive results as a partial replacement of cement. Therefore, it can be incorporated for construction purposes. For M40 grade of concrete with replacements of coconut fiber ash, the water cement ratio of 0.40 was insufficient for the mixes to produce proper and good workability. Hence, the inclusion of super plasticizer was needful.

It is observed that partially replacing cement with at most 20% of coconut fiber ash without the addition of fly ash yields a better compressive strength of 29 N/mm2 at 28 days and 38.21N/mm2 at 90 days

From the investigation, it can be noted that, by the addition of 20% coconut fiber ash and 10% fly ash as a partial replacement for cement yields a high compressive strength because at a curing date of 28 days, the compressive strength was found to be 22.09N/mm2 and 42.92N/mm2 at 90 days.

The increase in coconut fiber ash and fly ash of more than 20% does not produce a good compressive strength, which also proves that using a higher amount of coconut fiber ash only or even blended with fly ash cannot be used for construction purposes.

The maximum decrement of compressive strength in this investigation is 18.07N/mm2 at 28 days and 24.47N/mm2 at 90 days which is produced from the addition of 40% coconut fiber ash and 10% fly ash by weight of cement.

From the alkaline attack results, it shows that sodium hydroxide penetrated more in concrete cubes of higher percentages of both coconut fiber ash only and coconut fiber ash plus fly ash replacements. The two lowest percentages loss in strength from the alkaline attack were from conventional concrete which is 3.08% and 20% coconut fiber ash and 10% fly ash replacement which is 6.79%. The two highest percentages loss in strength form the alkaline attack is 12.03% from the replacement of 40% coconut fiber ash replacement by weight of cement and 15.38% from the replacement of 40% coconut fiber ash and 30% fly ash by weight of cement.

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