Behavioral Analysis of Partial Replacement in Concrete Materials

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Abstract- Infrastructure development across the world creates demand for construction material. The problem arising from continuous technological industrial development is the disposal of waste material, the raw material of concrete consists of cement, sand and crushed aggregate. Partial replacement or full replacement of this raw material by waste products may decrease the cost reduced, the energy consumption and also reduce the environmental pollution. The main objective of the studies is to encourage the use of waste product as construction material in cost effective manner. A referral M-25 concrete mix was used in the present investigation. Totally 102 cubes has been casted and tested their compressive strength. The physical and mechanical properties of the material used in concrete were investigated. In this study the replacement has been carried out for the cement by fly ash, sand by stone dust and coarse aggregate by coconut shell. An attempt was made to partially replace the cement by fly ash (10%, 20%, 30%), then fine aggregate by stone dust (10%, 20%, 30%), and coarse aggregate by coconut shell (10%, 20%, 30%) for each replacement and also combinations of all by 10% and 20%. 9 referral concrete cubes were casted for measuring 7, 14 and 28 days compressive strength. The result of replaced concrete is compared to the referral concrete.

Keywords – Coarse Aggregate, Cement, Coconut Shell, Compressive Strength, Fine Aggregate, Fly ash, Stone Dust

I. INTRODUCTION

Conventionally concrete is mixture of cement, sand and aggregate. Properties of aggregate affect the durability and performance of concrete. Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Some of the waste products are Coconut Shell, Stone Dust and Fly Ash. Each waste product has its own specific effect on properties of fresh and hard concrete. The waste materials used in concrete not only makes it economical but also solves some of the disposal problems. Fine and coarse aggregate constitute about 75% of total volume. It is therefore, important to obtain right type and good quality aggregate at site, because the aggregate form the main matrix of concrete or mortar.

In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth, in this situation developing country like India facing shortage in good quality natural sand. Particularly in India, natural sand deposits are being depleted and causing serious threat to environment as well as the society. So, as an alternative material stone dust have been used in concrete mixtures as a partial replacement of natural sand.

Coconut shell are not commonly used in the construction industry but are often dumped as agricultural wastes. Coconut is grown in 92 countries with a global production of 51 billion nuts of which India Produces 9500kt of coconut. In India industries and informal sectors recycle about 15-20% of solid waste in various building material. So Coconut shell has been used in concrete mixtures as a partial replacement of Coarse aggregate.

Present days construction industries needs faster development and also require high strength of concrete to facilitate the fast construction and economically construction. For that purpose we used high early strength of cement, to gain early strength of concrete. This demand of high early strength gain of concrete put forth the use of low w/c ratio. But when Use of fly ash in concrete imparts several environmental benefits and thus it is eco-friendly. It saves the cement requirement for the same strength thus saving of raw materials such as limestone, coal etc., required for manufacture of cement. Fly ash is a pozzolanic material & it improving the properties of concrete like compressive strength & Durability. So it has been partially replaced instead of cement.

II. LITERATURE REVIEW

A. Coconut Shell

(i) B.Damodhara Reddy (Jan. 2014) studied the use of Coconut Shell as coarse aggregate by replacing 25%, 50%, 75% and 100% of coarse aggregate with Coconut shell. A nominal mix of 1:2:4 was used and free water cement ratio

was maintained constant at 0.6. Tests were conducted for workability, flexure, compression and split tensile strength. Increase in CS percentage decrease densities of the concretes. The overall strength decrease with increase in CS replacement. Replacement of 25% CS gives higher strength compared to other percentage.

(ii) Parag S. Kambli (March, 2014) investigated the maximum compressive strength was found at a coconut shell replacement percentage of 20% and the compressive strength came as 19.7 N/mm2. From the experimental results and discussion, the coconut shell has potential as lightweight concrete, also using coconut shell as coarse aggregate in concrete can reduce material cost in construction.

B. Stone Dust

(i) Radhikesh P. Nanda (2010) had studied the experimental study on stone crusher as replacement of fine aggregate in concrete by replacing as 25%, 50%, 75% and 100%. A concrete mix of 1:2:4 by volume was used with water cement ratio of 0.60. Compressive strength, flexure strength and split tensile strength were conducted. Replacement of 25% stone dust gives maximum strength as compared to other percentage with value of 35.0 N/mm2.

(ii) Sandeep Kumar Singh, (2014) studied on experimental investigation on stone dust as partial replacement of fine aggregate in concrete. M25 grade concrete mix is used, the replacement percentage were 30, 40, 50, 60 and 70% were investigated. Compressive strength test were conducted on all the percentage replaced and the value is not much affected in replacement of 40%. The 30% replacement concrete compressive test is less in 7 and 28 days but it is more in 40% replacement.

C. Fly Ash

(i) Baboo Rai, (2014) had studied on effect of fly ash on mortar mixes by replacing cement with few percentages like 15%, 20% and 25% with fly ash. Compressive strength test were carried out on curing of 3 days, 7 days and 28 days. There is overall increase in strength at 3 days, 7 days, 28 days and 50 days. It is observed that at 50 days there is considerably increase in strength and the increases almost 32% for mortar mix of 30% fly ash.

(ii) Aman Jatale, (2013) investigated the effects on compressive strength when cement is partially replaced by fly-ash with 20%, 40% and 60%. Concrete cube specimens were made for each M-15, M-20 and M-25. Conclusions were made from the compressive test result that for M-15 replacement by 20% gives higher strength of 14.4 N/mm2. For M-20 replacement by 60% gives higher strength of 14.48 N/mm sq. and for M-25 replacement by 20% gives value of 14.04 N/mm2

III. Materials Used

A. Cement

The cement that used is of Portland Pozzolana Cement (PPC) 53 grade as per standard specification of India.

B. Fine aggregate

The natural fine aggregate are the river sand which is the most commonly used natural material for the fine aggregates that is used. For this study the river sand Zone-II is used for all the reference. Specific gravity is 2.76

C. Coarse Aggregate

Ordinary granite broken stone of size 20mm are used for the study. Specific gravity is 2.78.

D. Stone Dust

Stone dust was collected from the local stone crushing units. It was initially dry in condition when collected and was sieve before mixing in concrete. Specific gravity is 2.33.

E. Fly Ash

Fly ash is composed of the non-combustible mineral portion of coal. Particles are glassy, spherical ‘ball bearings’ finer than cement particles. Specific gravity is 2.

F. Coconut Shell

Available coconut shell were hammered and crushed to smaller pieces and sieved, they are used for the concrete.

G. Water

Potable water was used for mixing and curing

IV. Experimental Test

The strength of the referral concrete and other mixes was determined at the end of 7, 14, and 28 days of moist curing. The design mix proportion of 1:1.7:2.9 (where 2.9 is proportion of 20 mm) and W/C ratio of 0.45 is used for mix design M25 grade of concrete by satisfying the requirement of IS-10262-2009. Total 102 concrete cubes confirming to IS: 516-1964 of size 150x150x150mm were casted to determine the compressive strength. After 24 hours the moulds were de-moulded and subjected to water curing. Before testing the cube were air dried for 2 hours. Crushing loads were noted and average compressive strength of 3 specimens is determined at 7, 14 and 28 days.

Table 1. Details of mix designations for the materials replacement

Material Identification	Fly Ash	Coconut Shell	Stone dust
R.C	0%	0%	0%
$F.A_1$	10%	-	-
$F.A_2$	20%	-	-
$F.A_3$	30%	-	-
$C.S_1$	-	10%	-
$C.S_2$	-	20%	-
$C.S_3$	-	30%	-
$S.D_1$	-	-	10%
$S.D_2$	-	-	20%
$S.D_3$	-	-	30%
$COMBO_1$	10%	10%	10%
$COMBO_2$	20%	20%	20%

R.C – Referral Concrete, F.A – Fly Ash replacement, C.S – Coconut Shell replacement, S.D – Stone Dust replacement, COMBO – Combination of Fly Ash, Stone Dust and Coconut Shell replacement

V. Results and Discussion

Compressive strength test were conducted after completion of their curing period for 10%, 20% and 30% Replacement of Fly Ash, Stone Dust and Coconut Shell with Cement, Sand and Coarse Aggregate separately. M25 grade Gives for 0% replacement 22.6, 28.1 and 32.4 N/mm2 for 7, 14 and 28 days curing and shown in Fig (1)

Table 2. Compressive strength of referral concrete

Days	Compressive Strength (N/mm^2)
7	22.60
14	28.10
28	32.40

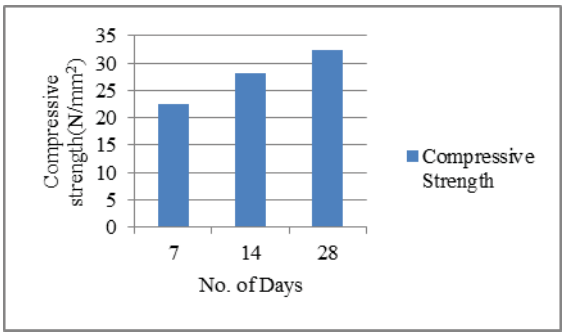

Fig.1 Compressive strength of Referral Concrete

After the replacement of Stone Dust, the compressive strength of concrete is 32 N/mm^2 for 10% at 28 days. Compared with the referral concrete, the percentage of decrement is negligible as given in the table (3) and bar chart shown in the fig. (2). Increase in replacement percentage reduces the compressive strength of concrete by 1.2% only for the replacement of Stone Dust

Table 3. Compressive strength of replacement of fine aggregate by stone dust

Days	Compressive Strength (N/mm^2)		
	10%	*20%*	*30%*
7	18.22	16.88	15.50
14	26.67	25.56	23.10
28	32.00	31.50	31.10

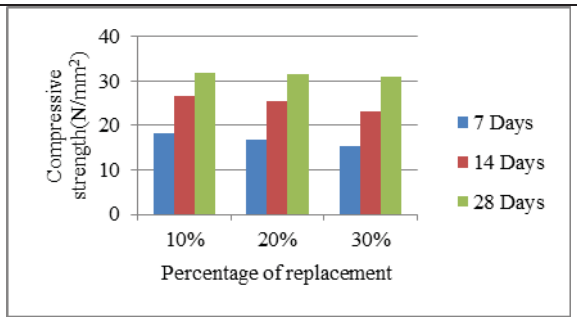

Fig.2 Compressive strength of stone dust replacement

Fig. (3) shows the variation of compressive strength of the replaced material accordingly to their age and replacement. For the Coconut Shell also 10% replacement only gives the maximum result as compared with the 20% and 30%. The decrease in compressive strength compared with the referral concrete is only 16%

Table 4. Compressive strength of replacement of coarse aggregate by coconut shell

Days	Compressive Strength (N/mm^2)		
	10%	*20%*	*30%*
7	20.88	17.33	14.22
14	24.44	19.11	17.77
28	27.11	23.11	20.00

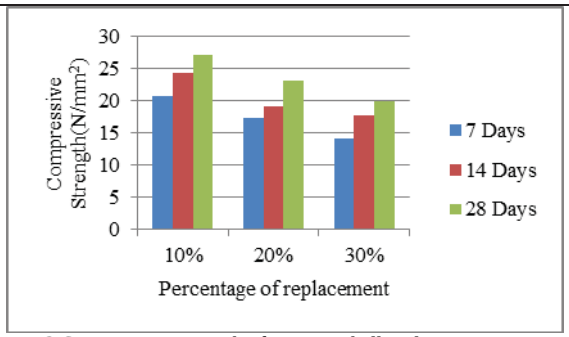

Fig. 3 Compressive strength of coconut shell replacement

Fly ash replacement also reduces the compressive strength compared to the referral concrete, but the reduction is minimum with compared to the referral concrete. 10% replacement of Fly Ash attained 7, 8, 28 days compressive strength of 21.8, 25.77, 31.1 N/mm2 is decrease percentage is 4% only with compared to referral concrete.

Table 5. Compressive strength of replacement of cement by fly ash

Days	Compressive Strength (N/mm^2)		
	10%	*20%*	*30%*
7	21.78	20.00	16.88
14	25.77	23.11	17.77
28	31.1	24.89	18.67

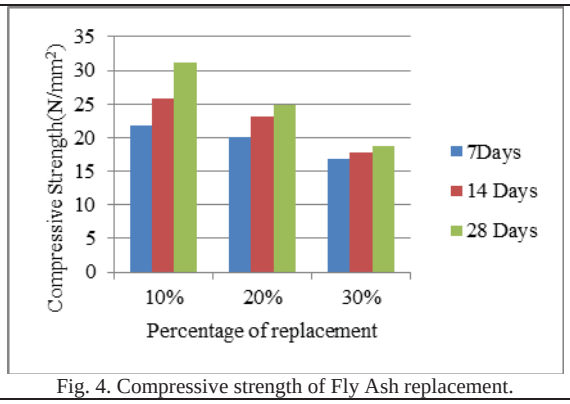

Fig. 4. Compressive strength of Fly Ash replacement.

After combination of 10% and 20% of Fly Ash, Stone Dust and Coconut Shell together in cube gives several values and the graph is shown in the Fig (5)

Table 5. Compressive strength of replacement of cement by fly ash

Days	Compressive Strength (N/mm^2)	
	10%	*20%*
7	8.80	8.44
14	11.55	9.77
28	18.08	15.03

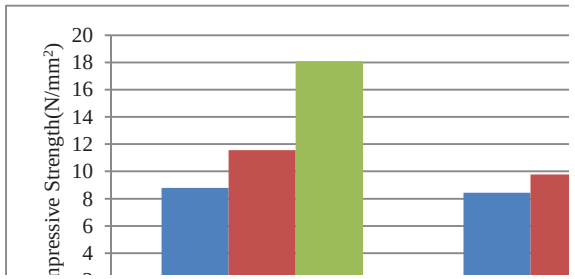

Fig. 5. Compressive strength of combination of replacement materials

VI. Cost Analysis

The cost reduction in the production of concrete by 10% replacement of cement, fine and coarse aggregate varies between 3% to 5% as compared with the referral concrete.

Table 6. Cost variations for material replacement of each cube

Material Identification	Rate Analysis (Rs.)			
	0%	10%	20%	30%
C.C	71	-	-	-
F.A	-	70.9	69.13	68.168
S.D	-	70.74	70.56	70.26
C.S	-	69.41	67.87	66.32
COMBO	-	66.23	65.42	-

VII. Conclusion

From the general study, it is elaborated that partial replacement only can be carried out and full replacement definitely reduces the strength of concrete. The 10% of replacement of concrete materials by Fly Ash, Stone Dust and Coconut Shell was found to be good with compared other combinations. Since, minute non-uniform variations are observed in the strength of replaced concrete. It can be effectively used for the low strength concrete mixes and cost-effective building construction.

VIII. Future Scope Of The Project

Our study had many limitations of which the time was a major concern. The properties of the replacement material are to be tested before practically applying out project. We can also study about the use of other replacement material like Coir pith, volcanic debris etc., for the further extension of the project.

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