Replacement of Fine Aggregate by Allied Materials

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***Abstract*—The importance of concrete as construction material is increasing every day due to the increasing population that causes chronic shortage of building materials. As a result, the civil engineers have been challenged to convert the industrial wastes to useful building and construction materials. This paper represents the experimental studies carried out from the use of rice husk as partial replacement for fine aggregate in concrete mix. This fine aggregate was replaced by 0%, 5% and 10% by weight for the M-30 mix. The cubes were tested for compressive strength for 7 and 28 days and the result obtained was compared with the nominal mix M-30. The result shows that compressive strength and workability decreases as the rice husk percentage increases. Optimum replacement of sand with rice husk was found to be 5%.**

Keywords—Replacement; rice husk; fine aggregates; compressive strength

I. INTRODUCTION

The human intellect is a genuinely magnificent thing; people have left no stone unturned in terms of innovation since the birth of humanity, from the discovery of fire to the invention of the wheel. Because of the continuous evolve with the passage of time, there is no such thing as the pinnacle of human civilization. Nowadays the need for shelter has changed throughout history and in the present times every one use different materials like wood, bricks, concrete and steel to construct houses and skyscrapers. Fired bricks are among the most durable and also are strongest building materials, since 4000 BC they have been widely known as artificial stones.

Goa, a state that lies on the western coast of India, and has nearly two-thirds of its landmass covered in laterite. This laterite is mainly used as construction blocks while the bricks used are made of clay. Clay when heated gains strengths and hardness. Clay in its pure has a mineral composition of quartz, mica, feldspar etc., while the composition of laterite includes quartz, zircon and oxides of titanium, iron, aluminum and manganese. The idea is to create a brick using laterite soil which is found in abundance in order to save cost as well as reduce pollution. By using additives such as foam, the weight of the brick can be drastically decreased and by using human hair it can be used a waste product as a binder. By using materials never implemented before this present work aims to achieve a new type of brick having high compressive strength and being lightweight. By using materials found locally in the state such as rice husk, lime intends to reduce the transportation cost and in turn reduce the overall cost of the brick. Present study also intends to reduce the expenditure by utilizing waste products and hence positively affect the environment.

The development in the construction industry all over the world is progressing. Attempts also have been made by various researchers to reduce the cost of its constituents and hence total construction cost by investigating and ascertaining the uses of materials which could be classified as local materials. Some of these local materials are agricultural or industrial wastes which includes saw dust, rice husk, coconut shells etc. As a result of the increase in cost of construction materials; there is a need to investigate the use of alternate building materials which are locally available. The availability of river sand for the preparation of concrete is becoming scarce due to the excessive non-scientific methods of mining from river beds, lowering of water tables. In the paper [1] the effect of rice husk as a substitute for fine aggregate in concrete mixture was carried out. Authors mentioned that water cement ratio is the factor affecting the quality of the concrete with a substitute of rice husks as a fine aggregate. The rice husk is applicable to concrete for interior concrete walls. Moreover, the application was intended to non- entrained placement. The wet weather conditions cause deterioration of husks that affect the stability of the concrete. In other paper [2] author conducted an experimental study on rice husk as fine aggregates in concrete. There exists a high potential for the use of rice husk as fine aggregate in the production of lightly reinforced concrete. Weight-batched rice husk concrete and volume-batched rice husk concrete show similar trends in the variation of bulk density, workability and compressive strength. Loss of bulk density, workability and compressive strength is higher for Weight-batched rice husk concrete than volume-batched rice husk concrete. Effect of rice husk on properties of concrete was explained in paper [3]. Authors concluded that due to addition of rice husk, concrete becomes cohesive and more plastic and thus permits easier placing and finishing of

concrete. It also increases the workability of concrete. Due to the addition of rice husk it is observed that early strength gain is slightly increasing with addition of 10%, 20% & 30% rice husk in normal concrete at 7 days. The optimum replacement level of rice husk is found to be to 10% for M30 grade of concrete. The effect of rice husk in concrete as cement and fine aggregate was studied in other paper [4]. Authors observed that the gradual decrease in the compressive strength as the percentage of replacement increases at 7 and 28 days. The gradual increase in split tensile strength as the percentage of replacement increases at 7 and 28 days. The maximum compressive strength is obtained at 5% replacement of fine aggregate by rice husk. The maximum split tensile strength obtained at 15% of replacement of fine aggregate by rice husk. The workability of rice husk concrete has decreased if the percentage of replacement increases. Rice husk as fine aggregate sustainable material for strength enhancement of conventional and self-compacting concrete was carried out in paper [5]. The test results indicate that up to 30% replacement of fine aggregate with rice husk enhances the strength in conventional concrete whereas the strength enhancement in self-compacting concrete up to 20% replacement. Experimental study on the properties of concrete with the partial replacement of sand by rice husk was studied in paper [6]. Authors concluded that the workability and water absorption of concrete increases while the bulk density, compressive strength and flexural strength decrease with the increase in percent replacement of sand by rice husk. With the increasing amount of rice husk content, the lightweight concrete is formed which could be suitable for building non load bearing light structures. This study suggested that rice husk could be one of the suitable alternatives to natural sand in construction industries as a constituent of lightweight concrete. Experimental study of rice husk replacement in concrete [7] was studied. Authors found that rice husk is found to be superior to other supplementary materials like slag, and silica fume. Due to low specific gravity of rice husk which leads to reduction in mass per unit volume, thus adding it reduces the dead load on the structure. Rice husk has been used directly or in the form of ash either as a value added material for manufacturing and synthesizing new materials or as a low cost substitute material for modifying the properties of existing products.

The present research paper investigates the potential use of agricultural waste to produce a low cost and light weight composite for construction and engineering purposes. The objectives of present study are stated below:

- To use rice husk as partial replacement of fine aggregate when making concrete mix.
- To cast specified numbers of cubes by replacing fine aggregate with rice husk by 5% and 10%, and compare their properties with standard mix (M30).
- To compare the strength characteristics with normal concrete and concrete with agricultural waste (rice husk).
- For each percentage compare the compressive with conventional concrete at 7 and 28 days of curing.

II. MATERIALS

Present study aims to manufacture concrete blocks with partial replacement of sand using locally available waste materials. The main aim is to create a product which will enhance the economic value of waste material. Different types of materials have been used in this study. Materials used included are as follows:

A. CEMENT

Ordinary Portland Cement' (OPC) of JK Cement brand was used in the preparation of concrete mixes used in the experimental investigation. The cement used was fresh and free from any lumps. All the tests were done as per the specifications given in IS 1489 Part I- 199141 for PPC. The specific gravity of cement is 2.85.

B. COARSE AGGREGATES

Coarse aggregates of 20 mm and 10 mm obtained from a local quarry are used in this experimental investigation. These aggregates were tested as per IS 2386-1963 (part I, part III) the aggregates were mixed in the ratio of 60:40 (percentage wise). The specific gravity of coarse aggregates is 2.65.

C. FINE AGGREGATES

Natural sand obtained from local sources was used in this experimental work. The required tests were done on sand as per IS 383 - 1970 specifications and sand confirming to zone IV was obtained. The specific gravity of fine aggregates is 2.51.

D. RICE HUSK

Rice husk is the waste obtained from the external covering of rice grains amid the processing procedure. Rice husk obtained from local sources was used in the experimental work and required tests were done on it. The specific gravity of fine aggregates is 1.33.

Fig.1: Rice Husk

E. WATER

Water used for mixing and curing of concrete during the course of the project was clean potable water free from all the impurities like oil, grease, salts and others. For missing and curing of concrete potable water is considered as per IS 456 - 2000. Hence tap water (potable) was used in the project.

F. SUPERPLASTICIZER

Super plasticizer used is sp 11.

III. EXPERIMENTAL PROGRAM

a) Mix Proportions

The mix was designed as per IS: 10262-2009, IS 456-2000. The grade of concrete we adopted was M30 with the water cement ratio of 0.40. Table 1: shows mix design proportion for $1m^3$.

TABLE 1: MIX PROPORTION

W/C ratio	Cement	Fine aggregate	Coarse Aggregate
0.40	405.48 Kg/m^3	553.40 Kg/m^3	1241.58 Kg/m^3
0.40	1	1.36	3.06

Proportion considered for the investigation is 1:1.36:3.06.

b) Casting of Specimens

Concrete specimens of 150 X 150 X 150mm cubes were casted. After 24 hours the specimens were demoulded and subjected to curing for 7 and 28 days in freshwater.

Fig 2: Casting of cubes

c) Testing of Specimens

The cast specimens are tested in compression testing machines as per standard procedures, after they are removed from curing tubs and wiped off the surface water.

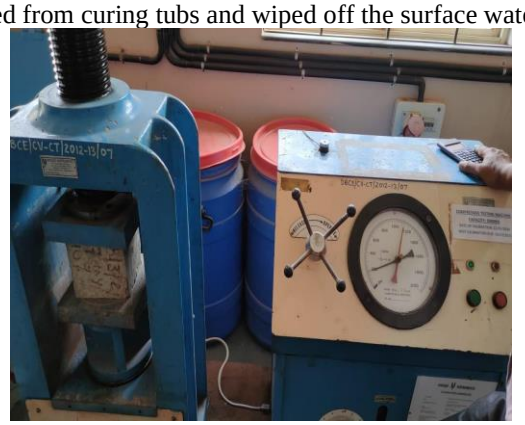

Fig. 3: Testing of Specimens

IV. RESULTS

1) Specific Gravity

a) Specific gravity of fine aggregate was found out to be 2.51, b) Specific gravity of coarse aggregate was found out to be 2.65, c) Specific gravity of cement was found out to be 2.85, d) Specific gravity of Rice husk was found out to be 1.33

2) Particle Size Distribution

a) Particle Size Distribution of Fine Aggregate

TABLE 2: PARTICLE SIZE DISTRIBUTION OF FINE AGGREGATES

Sr. No.	Sieve size	Wt. of sand retained kg	Percentage of sand retained	Cumulative percentage	Percentage fineness
1	4.75mm				
2	2.36 mm				
3	1.18 mm				
4	600 micron	0.06	6	6	94
5	300 micron	0.691	69.1	75.1	24.9
6	150 micron	0.206	20.6	95.7	79.4
7	Empty pan	0.045	0.45	100	99.55

b) Particle Size Distribution of Coarse Aggregate

TABLE 3: PARTICLE SIZE DISTRIBUTION OF COARSE AGGREGATES

Sr. no	Sieve size (mm)	Weight of aggregate retained (kg)	Percentage of weight retained	Cumulative %	Percentage fineness
1	20	0.40	40	40	60
2	16	0.43	42.1	82.1	17.9
3	12.5	0.17	17	99.1	0.9
4	10	0.009	0.9	100	0

3) Compressive Strength

The cube specimens were casted in compression testing machine after specified curing period in accordance with IS specifications. The test results are given in the table.

a) Compressive strength of concrete without replacement of sand

TABLE 4: COMPRESSIVE STRENGTH OF CONCRETE FOR NOMINAL MIX

Sr. No.	Load (N)	Area (mm^2)	Days of curing	Compressive strength (N/mm^2)
1	540000	22500	28	47.45
2	480000	22500	28	43.07
3	510000	22500	28	45.26

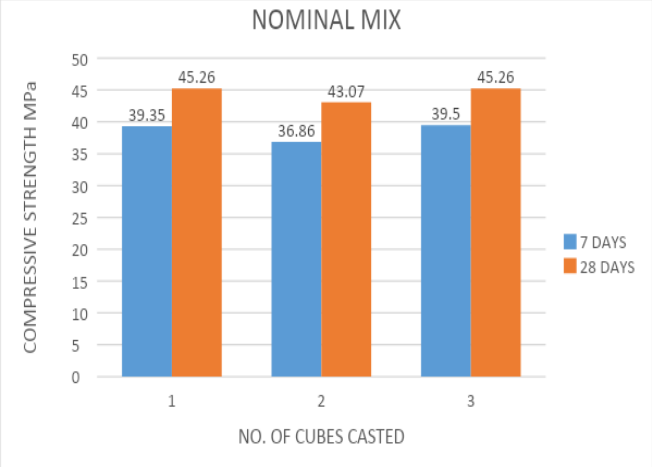

Fig4: Compressive Strength of Nominal mix

b) Compressive Strength of Concrete with 5% Replacement of Sand

TABLE 5: COMPRESSIVE STRENGTH OF CONCRETE WITH 5% REPLACEMENT OF SAND

Sr. No.	Load (N)	Area (mm2)	Days of curing	Compressive strength (N/mm^2)
1	730000	22500	7	32.44
2	720000	22500	7	32.00
3	750000	22500	7	33.33
4	950000	22500	28	42.22
5	840000	22500	28	37.33
6	800000	22500	28	35.55

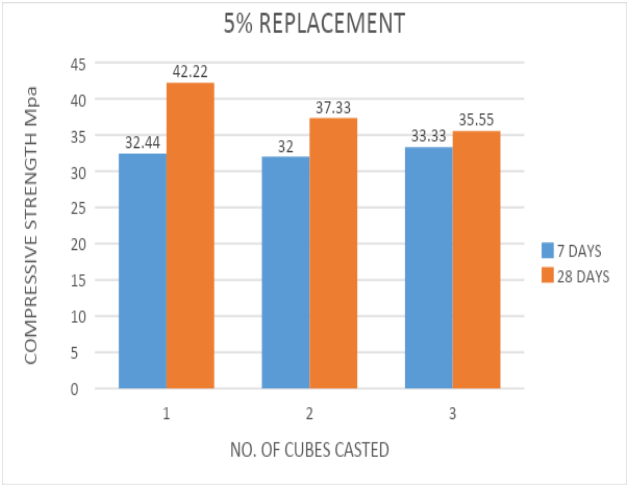

Fig.5: Compressive strength for 5% replacement of sand

c) Compressive Strength of Concrete with 10 % Replacement of Sand

TABLE 6: COMPRESSIVE STRENGTH FOR 10% REPLACEMENT OF SAND

Sr. No.	Load (N)	Area (mm^2)	Days of curing	Compressive strength (N/mm^2)
1	310000	22500	7	13.78
2	330000	22500	7	14.67
3	300000	22500	7	13.33
4	400000	22500	28	17.78
5	410000	22500	28	18.22
6	440000	22500	28	19.56

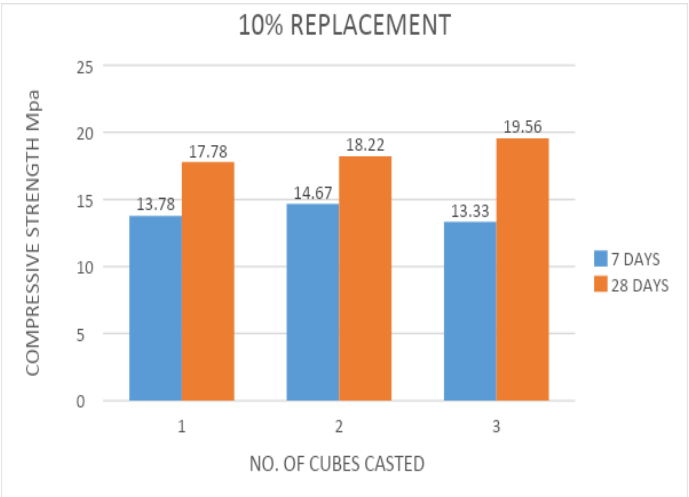

Fig.6: Compressive strength for 10% replacement of sand

d) Compressive Strength of Concrete with 3 % Replacement of Sand

The results of 3% replacement of fine aggregate with rice husk is interpolated from the results obtained from 5% and 10% replacement of fine aggregate with rice husk & nominal mix.

TABLE 7: COMPRESSIVE STRENGTH FOR 3% REPLACEMENT OF SAND

Mix	7 days	28 days
Nominal	38.57 N/mm^2	44.53 N/mm^2
5%	32.59 N/mm^2	38.37 N /mm^2
10%	13.93 N/mm^2	18.52 N /mm^2
3%	34.98 N/mm^2	40.83 N/mm^2

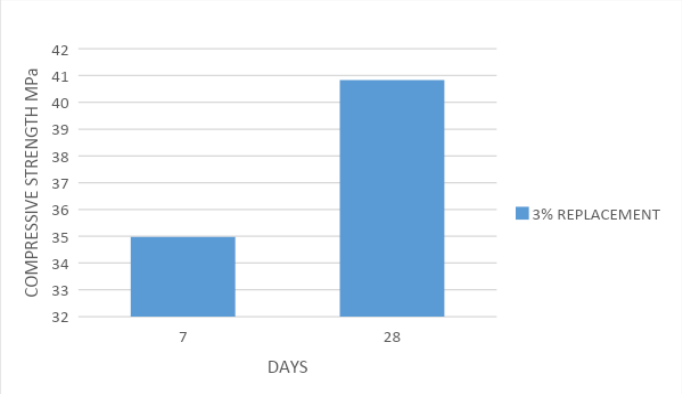

Fig 7: Compressive strength for 3% replacement of sand

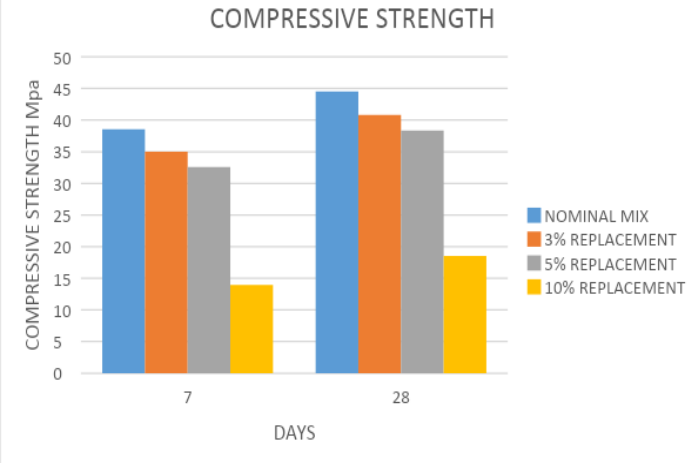

Fig. 8: Comparison of compressive strength

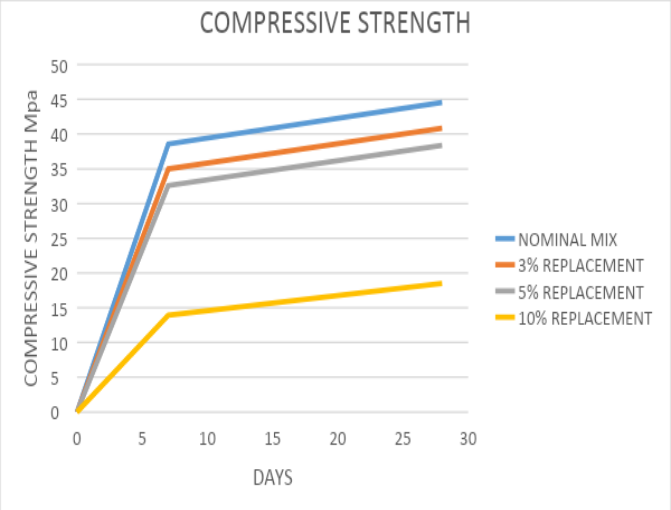

Fig 9: Graphical representation of compressive strength

V. DISCUSSIONS

From the results plotted in the graph shows the compressive strength decreases with increase in content of rice husk. In a paper [6] similar trend was noted in their experiment. The compressive strength was decreasing as the rice husk content was increasing. In another paper [4] the similar results are seen. The compressive strength for the normal mix was found out to be 45.26 N/mm^2. And also in their experiment the compressive strength for the normal mix was found out to be 44.15 N/mm^2, which is similar to the result found in present study. The average compressive strength for 5% and 10% replacement of rice husk at 7 days was 32.59 N/mm^2 and 13.93 N/mm^2. In a paper [3] the average compressive strength for 5% and 10% replacement of rice husk at 7 days was found to be 28.3 N/mm^2 and 17.2 N/mm^2. Both the papers show a similar trend in the compressive strength. The average compressive strength for 5% and 10% replacement of rice husk at 28 days was 38.37 N/mm^2 and 18.52 N/mm^2 and the average compressive strength for 5% and 10% replacement of rice husk at 28 days was found to be 42.8 N/mm^2 and 25.2 N/mm^2. Both the papers show a similar trend in the compressive strength. Decrease in strength must be due to high water absorption capacity of rice husk. In paper [2] it was concluded that rice husk absorbed more water which caused a decrease in the compressive strength. The 28 days compressive strength of 5% replaced concrete was more than the target strength of M30 concrete mix. And also in paper [6] authors found a similar trend in their experiment. The 28 days compressive for up to 10 percent replacement of sand by rice husk were found to be above the specified strength of M15 grade of concrete.

VI. CONCLUSION

Comparative study of concrete properties using rice husk as fine aggregate with replacement of 5% and 10% has been carried out. Compressive strength of concrete is decreased with the increment of rice husk replacement. For all percentage of rice husk replacement concrete strength is lesser than the conventional concrete in the mixer proportion of 1:1.36:3.06. The workability of rice husk concrete decreases with increase in replacement of sand. The 28 days compressive strength of concrete with 5% replacement of sand with rice husk was 38.37 N/mm^2 which is more than target strength for M30 concrete which is 38.25 N/mm^2. Therefore, concrete with 5% replacement of sand with rice husk can be used as a suitable alternative of conventional concrete.

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