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Solid Waste Management by Using Coconut Shell Powder as an Aggregate Material in Construction Bricks

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ABSTRACT- Coconut shell is an agricultural waste which is available in large quantities throughout the tropical countries of the world. It is thrown away or burnt as a means of solid waste disposal. Hence there is need of development of a new method of waste disposal for this coconut shells to benefit the agricultural as well as other industries. Earlier the coconut shell has been used as a lightweight aggregate in concrete as well as for making composite materials. In this work, we have done an experimental study regarding the potential of coconut shell powder as an aggregate material for making construction bricks. The bricks are made using coconut shell powder with soil in a ratio 5% (Sample 1), 10 % (Sample 2), 15% (Sample 3), 20% (Sample 4), 25% (Sample 5) and 30% (Sample 6) by volume. Test results have shown that compressive strength decreases with the increase of coconut shell powder. Bricks of Sample-1 give maximum average compressive strength of 4N/mm2 followed by Sample-3 2.36N/mm2, Sample-2 2.02N/mm2, Sample-4 and Sample-5 1.5N/mm2 and at Sample-6 0.6N/mm2. Also, Percent Water Absorption by weight is observed to be increasing with the increase in the volume of coconut shell powder. Water absorption in Sample-1 is minimum i.e. 16.35% and further increases in remaining samples as the amount of coconut shell powder increases. Thus Sample-1 bricks fulfil the criteria for compression test and water absorption as mentioned in IS 3495(1 to 4) – 1992. Thus it proves that using the coconut shell powder as an aggregate in construction bricks can be a way for solid waste disposal. This work puts a milestone for the further work in this area.

KEYWORDS- Solid waste disposal, Coconut Shell Powder, Construction Bricks

1 INTRODUCTION

India is among the top coconut producers and is a third largest producer of coconut in the world. Annual production of coconut is more than 21 billion nuts (2012-13).

The coconut shell which is the waste from coconut is having a critical problem of its disposal, and available throughout the coastal line of our country. It represents more than 60% of the domestic waste volume [2]. Considering which [3] 90% of coconut (in the form of empty fruit bunches, fibres, fronds, trunks, shell) was thrown away as solid waste or either burned in the open air causing pollution or left to settle in water ponds. Thus, the coconut processing industries' waste is contributing significantly to the CO2 and methane emissions. The abundant availability of coconut shell makes it a suitable and dependable alternative for aggregate in construction bricks. It will have the double advantage of waste management as well as pollution control.

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2 LITERATURE REVIEW

Coconut shell is used as an aggregate in concrete, and from the results, it can be concluded that the aggregate has considerable strength as a lightweight aggregate [4]. The writer has investigated the properties of concrete using the coconut shell as coarse aggregate. In the experimentation, pieces of coconut shell were used as coarse aggregate, the binder was Ordinary Portland Cement (OPC) 53 Grade, and fine aggregate was the river sand. The concrete which was having mixing ratio (cement: fine aggregate: coconut shell) 1:1.60:0.8, 1:1.60:0.7 and 1:1.47:0.65 satisfied the requirement of strength as per ASTM. Results from the experimentation proved that coconut shell fulfils the requirements for use as lightweight aggregate.

In an investigation on coconut shells as aggregate in concrete, the materials used were Portland cement, sand, granite and coconut shells. A concrete mixture of a ratio of 1:2:4 by volume, with a water-cement ratio of 0.6 was used as the control, to which the properties of all other mixes

were compared. Coconut shells did the replacement of the granite, 20%, 30%, 40%, 50% and 100% by volume. Results from the experimentation stated that 18.5% replacement of granite by coconut shell gave maximum compressive strength 20 Nmm-2 whereas the compressive strength of concrete produced by 20%, 30%, 40%, and 50% replacement was higher than 15Nmm-2, the minimum recommended for use in reinforced lightweight concrete construction [5].

In a review of Combination of coconut shell and grained palm kernel as lightweight aggregate in concrete, it was concluded that Combination of coconut shell and grained palm kernel had potential to be used as lightweight aggregate in concrete. It also reduced the material cost of construction because of the low cost and abundant availability of these agricultural wastes [7].

From all these references it was clear that except in concrete and for the composite material, coconut shell has not been used commercially. So it was decided that to go for a new application and check the feasibility of coconut shell powder to be used as aggregate in construction bricks.

3 METHODOLOGY

Soil used for making bricks is a mixture of Red Soil and Black soil with a ratio 80:20 by volume. It was obtained from farms at Malegaon (Nashik) this Soil is being used for making standard red bricks. The coconut shell powder was of 60 mesh size. Densities of the Soil and the coconut shell powder were 2.67gm/cm3 and 1.57gm/cm3 respectively. The water supplied by Malegaon Municipal Corporation was for mixing and curing. Studying the previous research, for the proportion of coconut shell powder as an aggregate with soil it was decided that the samples be made with the coconut shell powder as 5%, 10%, 15%, 20%, 25% and 30% aggregate.

In a study [8] it was observed that using the aggregate by volume produced a better performance concrete than that of by weight. Similarly, [5] replacement of granite with coconut shells by volume is used. If coconut shell powder were employed with soil by weight, due to its low density, it would have reduced the share of soil. Hence concerning [5] and [8], coconut shell powder is added as aggregate with the soil by volume.

Now, for deciding the proportion, a 50kg soil is taken as the base since for making traditional red bricks, an approximately 50kg soil is required to make 15 bricks. Thus for making the bricks, 50kg (18726.9 cm3) soil was the base size in which the aggregate coconut shell powder was to be mixed.

1. Sample 1 (5% CSP and 95% soil)

In this sample, 5% Coconut shell powder was to be added to the soil by volume. The amount of Coconut shell powder to be added was based on the volume of 50 kg soil. 5% volume that means 936.32 cm3 of coconut shell powder was required to be included in the soil and on the other hand 936.32 cm3 of soil needed to be removed from 50 kg soil. Then for ease of measurement of material the volume was converted into the mass of coconut shell powder and soil. It resulted in 1460.67gm of coconut shell powder to be added and 2500gm of soil to be removed. The electronic measuring gauge was used for measurement of mass. Thus 1st Sample was the mixture of 1.46 kg of coconut shell powder and 47.5 kg of soil. Using the same procedure the remaining sample mixtures were made.

Fig. 1 Mixtures of CSP and soil for making bricks

2. Sample 2 (10% CSP and 90% Soil) was made with 2.92 kg of coconut shell powder and 45 kg of soil.
3. Sample 3 (15% CSP and 85% Soil) was made with 4.48 kg of coconut shell powder and 42.5 kg of soil.
4. Sample 4 (20% CSP and 80% Soil) was made with 5.84 kg of coconut shell powder and 40 kg of soil
5. Sample 5 (25% CSP and 75% Soil)was made with 7.3 kg of coconut shell powder and 37.5 kg of soil.

6. Sample 6 (30% CSP and 70% Soil) was made with 8.76 kg of coconut shell powder and 35 kg of soil.

Fig. 2 Dies used for making bricks

Then water was added to all those mixtures and the clay was kept as it was for whole night before making bricks. Then bricks are made from those mixtures using aluminium dies. Dies having numbers 1, 2, 3, 4, 5 and 6 printed on them were used to make bricks. So that the bricks made of sample-1 were imprinted with number 1, the bricks of sample-2 were imprinted with number 2 and so on.

Fig. 3 Drying raw bricks before baking

Thus all the bricks were made and dried for two days before putting them to the kiln for baking. Then the bricks were put into the kiln for 15 days for baking. The bricks were kept at the 2nd-row form upside at one of the corners of the kiln.

Fig. 4 Kiln for baking bricks

Fig. 5 Bricks removed from the kiln

After getting removed from the kiln, the bricks were then ready for the testing.

4 TESTING

The testing of the bricks is performed referring the IS standard for testing of burnt clay bricks IS 3495(Part 1 to 4):1992. According to the given procedure, compression test, water absorption test and efflorescence test were performed. Hardness test was also performed.

For compression test, specimens were loaded axially; at a uniform rate of 14N/mm2 per minute till the failure occurred. The maximum load at failure was noted. The compressive strength is obtained by,

$$\sigma_c = \frac{\text{Maximum load at failure (N)}}{\text{Area of bed face } (mm^2)}$$

Fig. 6 Specimen of sample 1 during compression test

Fig. 7 Specimen of sample 1 after compression test

For water absorption test, the samples were first dried in an oven at a temperature of 105° C. till it obtained a constant mass. Then it was cooled to room temperature, and its mass (M1) was noted. After that, the specimens were immersed in clean water at room temperature for 24 Hrs. The samples were then removed, and the weighing was done 3 minutes after the removal. Again the mass (M2) of specimens was noted.

Water absorption, percent by mass, after 24-hour immersion in cold water is given by,

$$\frac{M_2 - M_1}{M_1} \times 100$$

Sample No.	% Share of CSP (by volume)	Avg. Compression Strength (N/mm^2)	% Water Absorption (by weight)
1	***5***	***4***	***16.35***
2	10	2.02	19.9
3	15	2.36	21.09
4	20	1.5	23.15
5	25	1.5	22.87
6	30	0.6	32.9

Table 1 Test results

5 RESULTS AND DISCUSSIONS

The compressive strength of brick depends on many parameters such as soil properties, mixture quality, baking, etc. Here the share of soil in each sample is gradually decreased, and proportion of coconut shell powder is increased. Experimental results show that compressive strength decreases with the increase in the share of coconut shell powder. The main reason behind this is the reduction in the proportion of soil, but in the case of Sample-2 and Sample-3, strength is increased slightly, maybe because of some problems in the mixture or during baking. The maximum compressive strength is obtained from Sample-1(5% CSP).

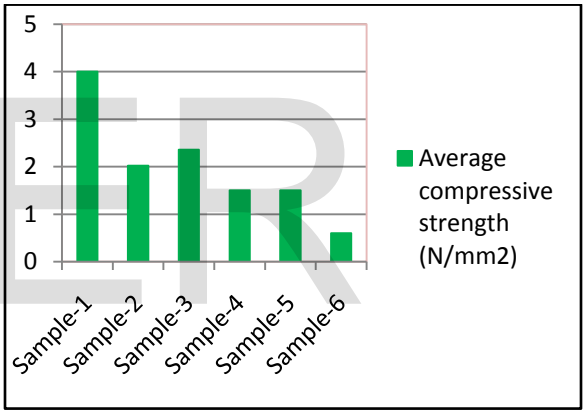

Fig. 8 Compression test results

% Water absorption increases with the increase in the increase in the share of coconut shell powder. This is because during the baking, coconut shell powder being burnt increases the porosity of the brick. The Sample-1 gives minimum water absorption i.e. 16.35%.

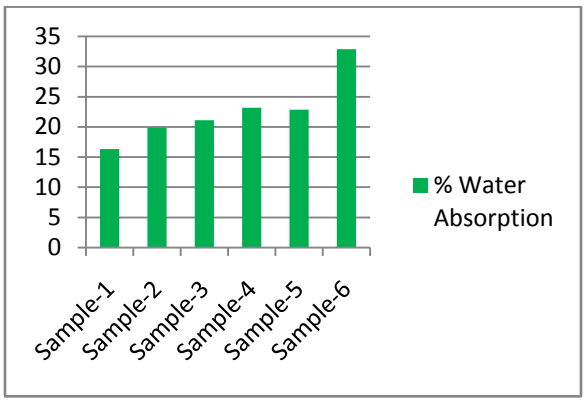

Fig. 9 Water Absorption test results

According to IS standards for testing of clay bricks, the compressive strength should not be less than 3N/mm2 and % Water absorption should not exceed 20%. Thus bricks of Sample-1 satisfy the criteria for strength as well as water absorption.

6 CONCLUSION

From this experimentation it is clear that Sample-1(5% CSP and 95% Soil) bricks fulfill the criteria for compression test and water absorption as mentioned in IS 3495(1 to 4) – 1992. Thus it is proved from the experimentation that coconut shell has a capability to be used as an aggregate in construction bricks. Thus this can be a new way of solid waste disposal of coconut shell.

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