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EFFECT OF CHARCOAL DUST ON COMPRESSIVE STRENGTH OF CONCRETE

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Abstract*— River sand has been the most popular choice for the fine aggregate component of concrete in the past, but overuse of the material has led to environmental concerns, Therefore, it is desirable to obtain cheap, environmentally friendly substitutes for cement and river sand that are preferably by-products. This paper discusses about the use of charcoal dust in concrete as a partial replacement of fine aggregates. Moreover it also discusses about the effect of charcoal dust on workability and compressive strength of concrete.

Keywords — Charcoal dust, slump, concrete, compressive strength, fine aggregates.

I INTRODUCTION

Concrete is the most popular building material in the world that consists of cement, fine aggregates, coarse aggregates and water. However, the production of cement has diminished the limestone reserves in the world and requires a great consumption of energy. The demand for natural sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity. Therefore, construction industries of developing countries are in stress to identify alternative materials to replace the demand for natural sand. On the other hand, the advantages of utilization of by-products or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load & waste management cost, reduction of production cost as well as augmenting the quality of concrete.

Charcoal is a light, black residue, consisting of carbon and any remaining ash, obtained by removing water and other volatile constituents from animal and vegetation substances. Charcoal is usually produced by slow pyrolysis, the heating of wood or other substances in the absence of oxygen. Charcoal ash has been proposed as an alternative to river sand that gives additional benefit to concrete. Charcoal ash is known to increase the strength of concrete over concrete made with equal quantities of river sand, but it causes a reduction in the workability of concrete.

II SCOPE

Large scale efforts are required for reducing the usage of the raw material that is present, so that large replacement is done using the various by-product materials that are available in the present day. Material like charcoal ash is very useful as the fine aggregates. Charcoal ash being a waste product will make the mixture economical. A regulated charcoal industry that required replanting and sustainable use of the forests would give the people clean efficient energy – and their energy industries a strong competitive advantage. Charcoal being a light weighted material; we can also produce light concrete with this substitution in different percentages.

III LITERATURE REVIEW

Using by-products or waste materials as a replacement of sand is quite a new trend since last decade. Large number of products has been used as a replacement of sand in concrete. With replacement of sand by 20% of plastic waste in concrete, the compressive strength of concrete increased by 35% as was seen by Thosar *et al.* (2017). Parbat *et al.* (2013) investigated that replacement of sand with finely ground waste glass shows increase in compressive strength.

There is an increase in density of concrete by the replacement of copper slag in concrete. Also there is increase in the flexural strength of the beam by 21% to 51% while replacement of copper as was seen by Biradar *et al.* (2014). They also investigated that sand replaced with 30% of Washed Bottom Ash (WBA) in concrete is the optimum amount to get favourable strength, saving in environment and reducing the cost, and It is observed that the compressive strength of concrete for all mix increases as the percentage of SGP increases, but decreases with the age of curing increases because of alkali silica reaction.

IV EXPERIMENTAL PROGRAMME

The experimental investigation consists of testing of basic materials in the laboratory and then fixing the optimum mix for concrete taking into account the criteria for concrete as per different IS-Codes. As per IS: 4031 (Part 1) the various tests are conducted on the cement like, consistency, fineness test, specific gravity and soundness test and Likewise specific gravity of fine and coarse aggregates, water absorption of both aggregates, sieve analysis and specific gravity of charcoal dust. The result of the tests is shown in Table no. 1.

Table no. 1: Properties of materials

S. No	Test	Value
1	Fineness of cement	97.875%
2	Consistency of cement	29.5%
3	Specific gravity of cement	3.12
4	Soundness of cement	2 mm
5	Specific gravity of fine aggregate	2.727
6	Water absorption of fine aggregate	1%
7	Specific gravity of coarse aggregate (20mm)	2.808
8	Water absorption of coarse aggregate (20mm)	0.8%
9	Specific gravity of coarse aggregate (10mm)	2.65
10	Water absorption of coarse aggregate (10mm)	0.5%
11	Specific gravity of charcoal dust	2.588

4.1. Design Mix According To IS 10262:2009

1. Concrete Proportion: 1:1.686:2.9789
2. Type of cement: OPC43 conforming to IS8112-1989
3. Maximum nominal size aggregate: 20mm
4. Mix cement content: 300kg/m^3 (table5 IS 456:2000)
5. Maximum water content ratio: 0.45 (table5 IS 456:2000)
6. Workability: 100mm slump
7. Exposure condition: Mild
8. Degree of supervision: Good
9. Type of aggregate: Crushed aggregate
10. Maximum cement content: 450kg/m^3 (cl.8.2.4.2 IS456:2000)

4.2 Trial Mixes

During the present study, 5%, 10%, 15%, 20% & 25% of traditional fine aggregates were replaced with charcoal dust. For each replacement 6 cubes were casted in order to check 3 each for every replacement on both 7^{th} and 28^{th} day. Chemical admixture was used in a constant amount i.e. 0.6% by weight of cement to maintain slump for the concrete. Workability of concrete depends on the water cement ratio and the water absorption capacity of the aggregates. The test for the workability of concrete is given by the Indian Standard IS 1199-1959 which gives the test procedure using various equipments. To check the compressive strength of the concrete, cubes of size 150mm X 150mm X 150mm were casted and proper curing was given to the cubes.

V RESULTS & DISCUSSION

Fresh property of concrete was tested using slump test. Slump value initially increased by 5mm on 5% replacement of fine aggregate with charcoal dust. At 10% replacement with charcoal dust the slump start decreasing. The cube-compressive strength for controlled concrete specimens and test specimens (with 5%, 10%, 15%, 20% and 25% replacement of fine aggregates with charcoal dust) have been ascertained at 7^{th} day and 28^{th} day and the results are shown in table given below. The results are represented in the form of a graph as well. From Table, it was found that the cube-compressive strength of controlled mix was obtained as 35.99 N/mm^2. On 15% replacement of fine aggregates with charcoal dust, it was found that the cube-compressive strength has increased by about 1.47% for 7^{th} day and 6.8% for 28^{th} day. So it is clearly visible that 15 % replacement of fine aggregates with charcoal dust gives the maximum strength to the concrete mix of M35.

Table no. 2: Slump value and compressive strength for different percentages of replacement.

Fine Aggregate %	Charcoal Dust %	Slump value (mm)	Compressive strength @7 days N/mm^2	Compressive strength @ 28 days N/mm^2
100	0	65	25.0	35.995
95	05	70	25.24	37.665
90	10	66	26.355	39.045
85	15	65	27.20	40.171
80	20	62	25.37	38.446
75	25	60	19.87	30.267

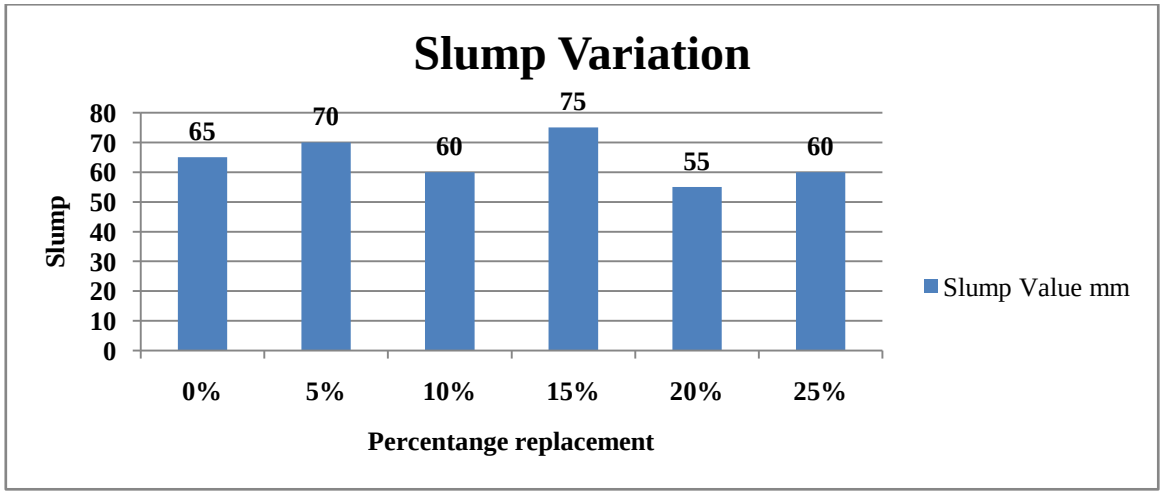

Fig. 1: Graph representing variation in slump value with changing charcoal dust percentage.

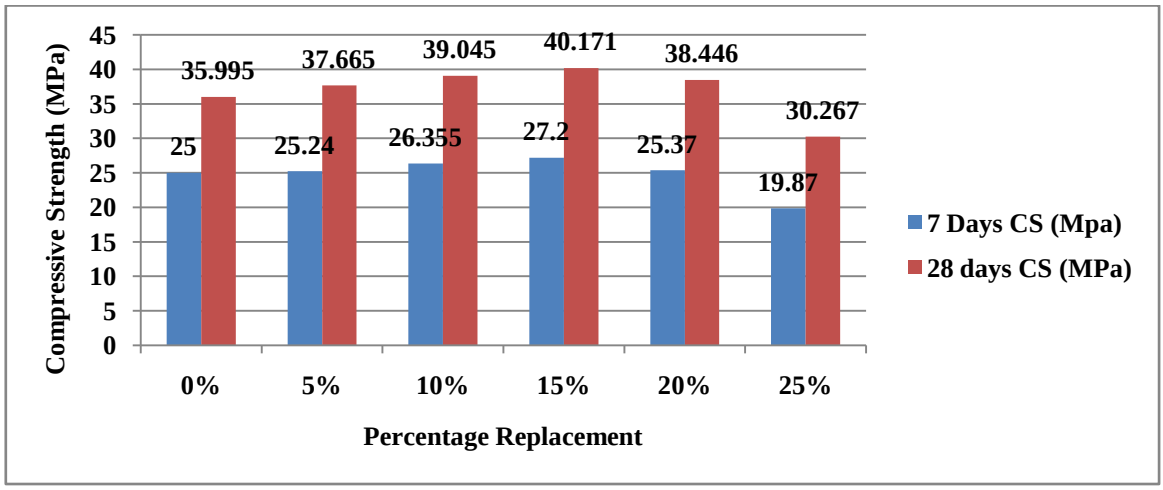

Fig. 2: Graph showing variation in compressive strength at 7 and 28 days with changing charcoal dust percentage

VI CONCLUSIONS

- One of the ways to improving sustainability is to reduce the human consumption of natural resources. In order to protect the natural resources such as river sand, this study has identified that charcoal dust, which is a waste product from burning of wood and other organic matter and available almost free-of-cost, as partial replacement for river sand.
- Also slump value initially increased but with increases in the amount of dust the slump of concrete start decreasing.
- This study has brought out positive results that charcoal dust increases compressive strength. So it can be effectively used as a partial replacing material up to 20% of natural river sand in M35 concrete.
- It was seen that replacing 15% of sand by charcoal dust gives highest compressive strength after 28 days. 6.8% increase was observed (after 28 days) in comparison to control mix at 15% replacement of sand with charcoal dust.
- Using charcoal dust as a replacement of fine aggregates in concrete can be also considered for the light weight concrete.
- The present research would like to highlight that this method of reducing the usage of river sand in concrete will not only cut down the cost of construction, but also reduce the level of illegal extraction of sand from the river beds, resulting in preserving the natural resources.
- Reusing industrial and household waste such as charcoal dust will bring down the need for landfill disposal, and to a great extent, avoid the conversion of fertile lands into dumping yards.

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