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Strength properties of concrete with partial replacement of sand by bottom ash

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Abstract— ***Bottom ash is the ash left behind at the bottom of a boiler when coal is burnt. It constitutes to about 10 to 20 % of the unburnt material or ash where as 80 to 90 % is recovered as fly ash. At present the bottom ash is disposed as a waste in barren lands. In some countries it is used as a material for embankment construction in highways. The land filling causes serious environmental issues. The research work carried out included an experimental investigation on strength properties of concrete made with 10% to 50 % replacement of manufactured sand by bottom ash. The tests were carried out to find the compressive strength, splitting tensile strength and flexural strength on specimens.***
Results showed that up to 30 % replacement of sand by bottom ash there was only marginal reduction in compressive strength, splitting tensile strength and flexural strength.
The experimental works were carried out with manufactured sand and bottom ash confirming to zone II at various proportions as fine aggregate in concrete. The study showed that bottom ash can be used along with sand in concrete with comparatively low strength requirement.

Keywords— bottom ash; concrete; waste; strength.

I. Introduction

Concrete is the most widely used building material in the world. Aggregates are the majour component of concrete. The sand mining in rivers had gone up to such an extent that in many countries there is ban on sand mining. Even in areas where there is no ban, nowadays good sand is not readily available; it is transported from a long distance. With the recent ban on river sand mining in India alternate sources are looked into. Attention has turned to how we can use manufactured sands as an alternative to natural sands. Making manufactured sands by crushing rock boulders to sand granules came into practice.The artificial sand produced by proper machines can be a better substitute to river sand. Demand for manufactured fine aggregates for making concrete is increasing day by day. So, now rock mining had also turned out as an environmental problem in many cases.

If an adequate industrial or agricultural by-product which is a waste material can replace sand partially it will reduce the problems due to the scarcity of sand. It will also be an environment friendly method of disposal of large quantities of materials that would otherwise pollute land, water and air. If this waste can be used as a partial sand replacement material in concrete it will be a valuable resource. This thesis aimed to try bottom ash as an alternative material to substitute for sand.

Yogesh Aggarwal & Rafat Siddique in paper on 'microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates'[1] has given a study report. This paper presents the experimental investigations carried out to study the effect of using bottom ash as a partial replacement material for fine aggregates.

Compressive strength, splitting tensile strength and flexural strength of concrete specimens with bottom ash were lower than control concrete specimens at all the ages. Mix containing 30% and 40% bottom ash, at 90 days, attains the compressive strength almost equivalent to of compressive strength of normal concrete at 28 days. Furthermore, it was observed that the greatest increase in compressive, splitting tensile and flexural strength were achieved by substituting 30% of the natural fine aggregate with bottom ash as fine aggregate.

II. SIGNIFICANCE OF THE PROJECT

Lot of research works are carried out on strength of concrete with manufactured sand which is crushed stone aggregate as fine aggregate due to acute shortage of good quality river sand or due to ban on mining of river sand. It is proved that manufactured sand (M sand) is a good substitute to river sand. But quarrying of rock are also causing serious environment problems. Large scale quarrying is a threaten to ecology. It causes pollution when the fines which are waste are disposed by filling in barren land. It pollutes the land, water and atmosphere. Substitution of M sand by natural aggregates or industrial bi-products thus gained importance. Bottom ash is obtained from boilers of thermal power plants. Even now there are huge numbers of thermal power plants using coal as fuel. There are other industries also using coal as fuel.

Objectives of project work could be summarised as to

- Compare the strength properties of conventional concrete mix M30 with the properties of concrete with bottom ash partially replacing sand.
- Find the optimum percentage of bottom ash that can be replaced for M sand.

Scope of the work was to

- Make use of the coal bottom ash available from industries as fine aggregate in concrete.
- Evaluate the properties of fresh concrete and strength properties of hardened concrete.

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III. EXPERIMENTAL WORK AND RSULTS

A. Materials.

The cement used for the experimental work is ordinary Portland cement of grade 53. A single brand namely Ramco cement is used. Material tests for standard consistency, initial setting time, final setting time, specific gravity etc. were carried out and found as conforming to the requirement.

The type of fine aggregate used is manufactured sand from granite rock. Sieve analysis of M sand is carried out as per IS:2386 (Part I) and it is conformed to grade for Zone II. M sand was having a water content of 0.80% and water absorption of 1.20 %.

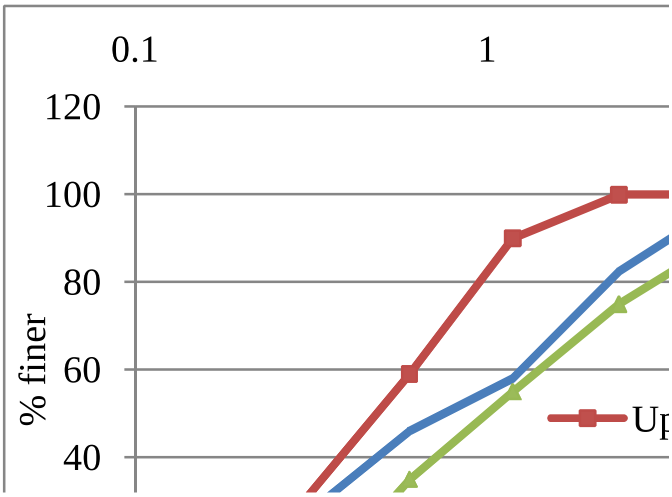

Fig.1. Grain size distribution curve (zoneII) M-sand

Sieve analysis of fine aggregate (bottom ash) is also carried out as per IS:2386 (Part I) and found to be in zone II.

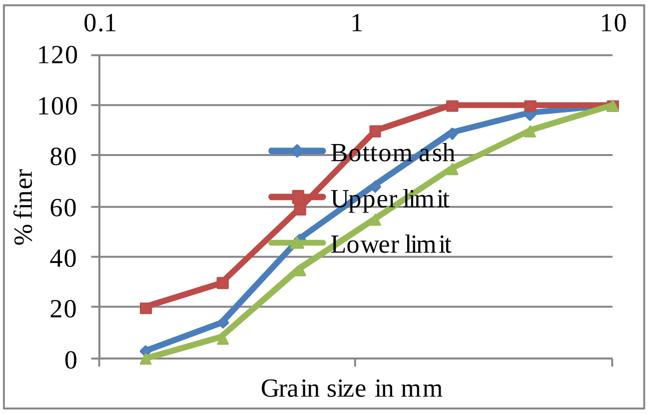

Fig.2. Grain size distribution curve (zone II) Bottom ash

For bottom ash water absorption was 1.40 %, and moisture content 0.3 %.

20 mm nominal size broken stone is used as coarse aggregate in the experiment. The distribution of grain size was found to be within the upper and lower limit of percentage finer on each sieve size and so conforms to the requirement as per IS specification for coarse aggregate. The specific gravity was 2.74.Water absorption was 0.80 % and there was no moisture content. The aggregate crushing value, aggregate impact value, flakiness index all are found to be within the specified requirement.

The superplasticiser used is master glenium SKY 8233 which is a high-performance super plasticizer based on polycarboxylic ether. The manufacturer is BASF chemical company and it is conforming to IS 9103:1999 and IS 2645 :2003. Specific gravity is 1.08 and recommended usage is up to 1.5% and as per trial on samples.

B Test parameters

Slump test is carried out to study the workability of fresh concrete and to check the uniformity of concrete from batch to batch. Compaction factor test is also done to study the workability of concrete. The compacting factor obtained for selected control mix was 0.93 which tallies with a slump of 100.For the various percentage replacement of M sand with bottom ash the 100 mm slump is obtained by varying the quantity of superplasticizer.

M30 mix was considered for the test. For mix design, severe exposure condition, placing of concrete by pumping, using superplasticiser and a water cement ratio of 0.45 are considered. Based on trial with superplasticiser a free water content of 180 litres gave a slump of 100 mm for the control mix using M sand.

The tests carried out were for compressive strength on 150 mm cubes, splitting tensile strength and flexural strength on standard specimens. The mixes are designated with the % replacement suffixed with BA for bottom ash. Testing was carried out on conventional mix (control mix) without any replacement and on mixes with 10, 20, 30 and 50% M sand replaced by bottom ash. The mix proportions used are given in table 1.

Table 1. Mix proportions in kg for different mixes used.

Mix	W/C ratio	Cement	Water	Course aggregate	M Sand	Bottom ash	Super Plasticizer %
Control	0.45	400	180	1072	19	0	0.40
10 BA	0.45	400	180	1072	737	71	0.45
20 BA	0.45	400	180	1072	655	142	0.50
30 BA	0.45	400	180	1071	573	213	0.60
50 BA	0.45	400	180	1071	409	355	0.70

C Test results and discussion.

The most common of all tests on hardened concrete is the compressive strength as many of the desirable characteristics of concrete are qualitatively related to it and mainly because of the intrinsic importance of it in structural design. For each mix nine specimens are cast and three cubes each are tested after 3, 7 and 28 days curing in compression testing machine. The different percentages of replacement of M sand by bottom ash considered are 10, 20, 30 and 50. The results obtained are tabulated in table.2 and the variation is plotted in fig.3.

Table 2. Compressive strength on cubes for different % replacement of M sand by bottom ash. (N/mm^2)

Curing days	**Control mix**	**10 BA**	**20 .BA**	**30 BA**	**50 BA**
3	23.40	18.32	17.25	17.13	16.01
7	31.67	25.68	26.12	27.28	23.90
28	41.73	36.30	36.72	38.43	32.97

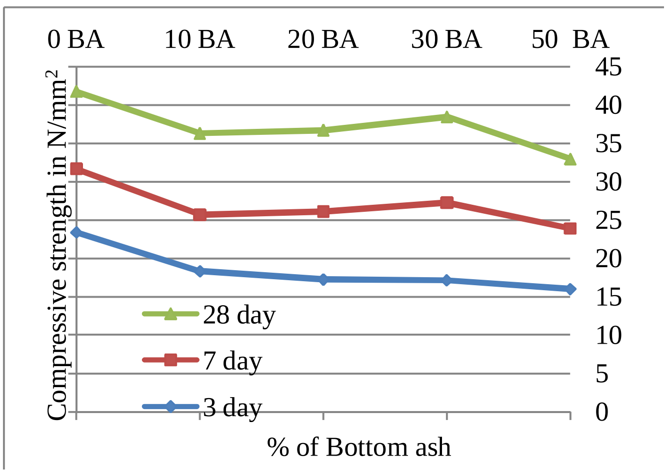

Fig.3. Compressive strength of concrete with replacement of M sand by bottom ash.

The bottom ash concrete gains strength at a slower rate in the initial period and acquires strength at faster rate by 28 days. Earlier studies have reported that due to pozzolanic action of bottom ash strength is comparable at 90 days. This study shows that the strength for 30% replacement is the most adequate and at this level the targeted mean strength is obtained.

The splitting tensile strength test is carried out by placing a cylindrical specimen cast in the standard mould for the purpose. Six specimens are cast for each mix. Three cylinders each are tested after 7and 28 days curing in compression testing machine. The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of the compression testing machine and load is applied until failure of the cylinder along the vertical diameter. The splitting tensile strength is calculated using the formula $F = 2P / \pi DL$. The result of splitting tensile strength of mixes with various percentages of replacement of M sand with bottom ash are tabulated in table 3 and shown in fig.4.

The increase of 0.7, 5.70 and 12.16 at 7 days curing are noted for 10, 20 and 30 % replacement. For 50% replacement there is decrease of 15.20 % at 7 days curing. At 28 days curing there is increase in splitting tensile strength for 20% and 30% replacement and only slightly less in 10 % replacement and 20.6% reduction when replacement is 50%.

Table 3.Splitting tensile strength for different % replacement of bottom ash (N/mm^2)

Curing days	Control mix	10 BA	20 BA	30 BA	50 BA
7	2.63	2.65	2.78	2.95	2.23
28	3.50	3.42	3.60	3.695	2.78

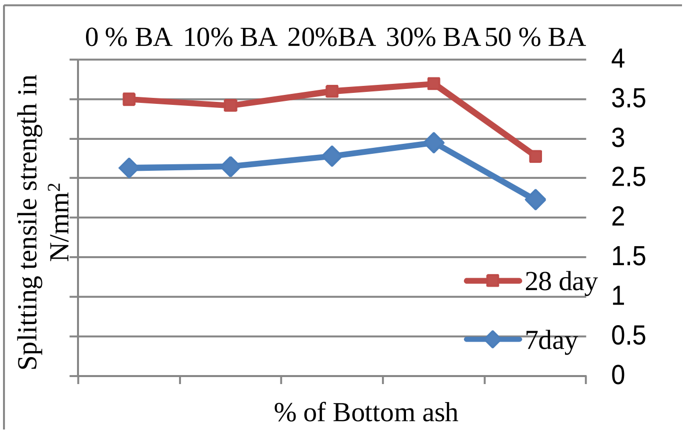

Fig.4. Splitting tensile strength for different % replacement of M sand by bottom ash (N/mm^2)

So it can be seen that up to 30% replacement of M sand by bottom ash there is no strength loss as far as splitting tensile strength is concerned.

Flexural testing of concrete beam is carried out in a flexural testing machine. Specimens of size 500 mm x100 mm x

Table 4. Flexural strength for different % replacement of M sand by bottom ash (N/mm^2)

Curing days	Control mix	10 BA	20 BA	30 BA	50 BA
7	4.67	4.61	4.50	4.44	3.92
28	6.90	6.56	6.39	6.66	5,99

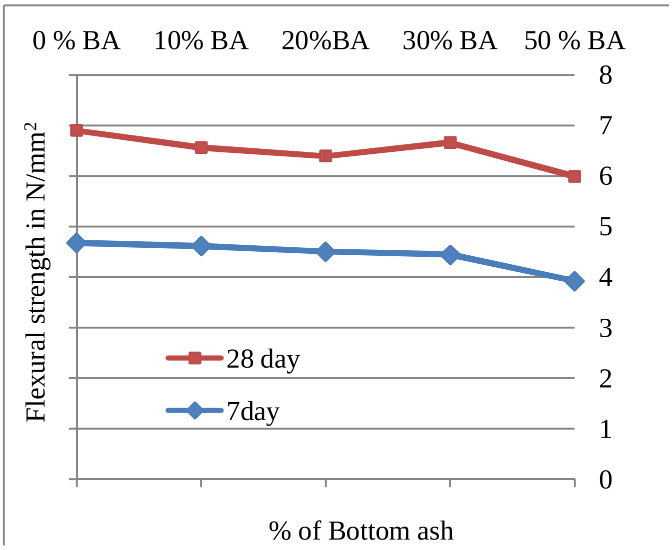

Fig 5. Flexural strength for different % replacement of M sand by bottom ash.

100 mm are cast and cured. Six specimens are made for each test to find the 7 days and 28 days flexural strength. Two

point load test is done. The specimen is wiped clean and then placed in the machine in such a way that the load is applied to the upper most surface as cast in the mould along two lines 13.3 mm apart.

The flexural strength of the specimen is expressed as the modulus of rupture and calculated as $f_b = PL/bd^2$

The flexural strength test results of bottom ash concrete are given in Table 4 and the variation is plotted and shown in Figure 5. It is observed that 30 % replacement of m sand by bottom ash gives comparable flexural strength at the age of 28 days. There is only slight decrease in flexural strength at 10, 20and 30% replacement levels. The flexural strength is affected to more extent with the increase in bottom ash in concrete. The bottom ash concrete gains flexural strength with the age that is comparable but less than that of conventional mix. It may be due to increased water requirement for bottom ash due to its shape and surface texture. It may also be due to the poor interlocking between the aggregates, as bottom ash particles are spherical in nature.

IV CONCLUSION

To investigate and identify supplementary by-product materials that can be used as substitutes for constituent materials in concrete is the need of the present. Bottom ash is an abundant waste from furnace of thermal power plants and other industries. Studies so far done have revealed that bottom ash will increase the durability in several cases.

Based on this experimental study, the following conclusions are drawn. The study shows that 30% replacement of M Sand with bottom ash has given a 28 day compressive strength of 38.43 MPa (target mean strength is 38.25kN/m^2). The result shows that bottom ash can be used to substitute M sand and the optimum replacement level is 30%.

The use of bottom ash in concrete will reduce the environmental problems arising from filling it in land. As a result of reduced sand consumption the problems in sand mining can also be reduced. The reduction of landfill costs and ill effects of land filling along with reduction in sand mining finally leads to sustainable development.

References.

[1] Yogesh Aggarwal, Rafat Siddique, “Microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregate” Construction and Building Materials Volume 54, 15 March 2014’, 210-223
[2] Aggarwal P, Aggarwal Y, Gupta SM. “Effect of bottom ash as replacement of bottom ash as replacement of fine aggregates in concrete.”Asian Journal of Civil Engineering, vol. 8 no. 1 (2007) 49-62.
[3] B.Kondraiveldhan, Velchurisaran “ Influence of pond ash on strength and durability of concrete”, Indian concrete journal Oct-t 2011 vol. - 30 76-85.
[4] A.U Abubaker, Khairul Salleh Baharudhen, “Properties of concrete using Tanjhun bin powder plant bottom ash”, international journal of construction engineering and technology, vol. 3-2- 2012.
[5] American Coal ash association, “2008 Coal combustion product and survey report” report of the association.
[6] Djwantoro Hardjito.C and Shaw Shen Fung on ‘Parametric Study on the Properties of Geopolymer Mortar Incorporating Bottom Ash’ Selected paper from the Asia Pacific Structural Engineering Conference, APSEC 2009.
[7] Bai Y, Basheer PAM. “Influence of furnace bottom ash on properties of concrete” Ice proceedings, structures and buildings, special issue new materials and new uses of for old materials 2003; 156(1): 85–92.
[8] Properties of concrete by Nevilla, Tata Mc Grah Hill, New Delhi
[9] Concrete technology , theory and practice by M.S Shetty, S.Chand & Company Ltd, New Delhi