STRENGTH AND DURABILITY STUDY ON PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE BY USING BOTTOM ASH

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***Abstract*— Concrete is widely used as a construction material in modern society with the growth in urbanization and industrialization and the demand for concrete is increasing day by day. This study reviews the characteristics of Concrete incorporated with Bottom Ash as partial replacement for fine aggregates, with a main focus on the mechanical properties such as Compressive strength, splitting tensile strength and flexural strength. This study is done on M25 grade concrete. The cubes, cylinders were casted and tested at 7, 14 and 28 days. The beams were casted and tested at 7 and 28 days. Fine aggregate is replaced with bottom ash by 10%, 20%, 30% in concrete. Raw bottom ashes, which are residues from coal thermal power plant, pose an enormous disposal problem and environmental load. The optimum result obtained from the replacement of 20% of bottom ash in concrete attained a maximum high strength than conventional concrete**
***Keywords*— bottom ash, strength, durability.**

I. INTRODUCTION

Concrete is a material synonymous with strength and longevity. In addition to being durable , concrete is easily prepared and fabricated from readily available constituents and therefore widely used in all types of structural systems. The indian construction industry is today consuming about 400 million tonnes of concrete every year and it is expected that this may reach a billion tonnes in less than decade . All the materials required to produce such a huge quantity of concrete come from the earth’s crust. Among the solid wastes, the most prominent materials are fly ash, bottom ash, blast furnace slag, rice husk ash, silica fume and materials from construction demolition. The challenge for the civil engineering community in the near future is to realize projects in harmony with the concept of sustainable development and this involves the use of high performance materials and products manufactured at reasonable cost with the lowest possible environmental impact. The cost of raw material sand high price of energy. In construction materials is now a global concern. Durability of concrete is defined as its ability to resist weathering action, chemical attack, or any other process of deterioration. Durability of concrete can be as material have long life against various environmental conditions.

II. LITERATURE REVIEW

In 2020**, khairunisa Muthusamy**, et al have investigated is need to improve the sustainability of concrete by incorporating waste by- products and at the same time controlling the use of precious river sand as well as invaluable land from becoming waste diposal area. Coal bottom ash is one such by products that can be used as river sand substitute in concrete. The chemical and physical properties of CBA are diverse from various sources and years of investigation as it is influenced by the coal combustion system.

Swami Nathen .A.N et al. (2017) Supplementary cementitious materials prove to be effective to meet most of the requirements of durable concrete. BA is available in plenty to other supplementary materials like silica fume and fly ash, Due to its high pozzolanic activity, and the strength and durability of concrete are improved. This paper presents an over view of the work carried out on the use of Indian BA to improve the strength and durability of concrete.

T. subramani et al., (2015) experimental investigation of partial replacement of cement with fly ash and sand with bottom ash glass used in concrete the 7 days cube compressive strength results showed reduced strength of concrete due to slow action. The strength of concrete containing fly ash 40% and 20% of bottom ash and 30% of glass was high composed with that of the conventional mix. The flexural strength of concrete with 40% fly ash content with 30% of glass showed improvement on the mechanical properties of concrete cement replacement level of 40% fly ash in concrete mixes was found to be the optimum level to obtain higher value of the strength and durability at the age of 28 days. By cost analysis it is found that by 40% replacement of flyash, cost is reduced upto 45% on cement. Also by using bottom ash is in this concrete to reduced the fine aggregate cost. To reduce the weight of concrete making an light weight concrete because here using glass as coarse aggregate.

Gyanen.Takhelmayum et al.(2014) The main of the experimental study is to develop strong and durable engineering properties BA as a material for concrete production the effects of BA on the fresh properties of concrete, mechanical properties, water absorption and sulphate resistant of concrete has been found out.The percentage of BA in the mix design varies from 5 to 30 % of total cement with an increment of 5% and it is found that the strength of concrete was found more when the age of curing period is increased there by reducing the surface water absorption and thus improves the resistance of sulphate attacks. effectively than the use of naphthalene- based superplasticizer with similar slight reduction in strengths. The addition of NaOH solution slightly improves the workability of the mix while maintaining the strength of the geopolymer mortars.

In 2010, turhan et al examined the effect of the non ground bottom ash (BA) as fine aggregate in mortar or concrete, the shrinkage cracking was observed on mortar specimens. The replacement was made by weight; the replacement ratios for BA as fine aggregate were (0-100%). From the test data the crack formation and occurrence times were delayed by increasing the BA conent.

In 2010, Safiuddin et al investigated the potential use of various solid wastes for producing construction materials. This paper discusses the environmental implications caused by the generation of various solid wastes, and highlights their recycling potentials and possible use of for producing construction materials. The major solid wastes generated were fly ash & bottom ash, granulated blast furnace slag, rice husk ash, palm oil fuel, waste glass organic fibers, quarry waste, construction and demolition debris, rubber tires.

III. MATERIAL COLLECTION

A. *Material*

Bottom ash, OPC M53 Grade cement, fine aggregate (sand), Aggregate (size 16 to 20mm).

B. *Cement*

Ordinary Portland cement of Birla gold conforming to IS269-1976 and IS 4031-1968 was adopted in this work . The cement used is 53 grade. Cement is a generic term that can apply to all blinders. The chemical composition of these cements can be quite diverse, but by far the greatest amount of concrete used today is made with Portland cements.

C. *Coarse Aggregate*

Aggregates generally occupy 70 to 80 percent of the volume of concrete and can therefore be expected to have an important influence on its properties. Aggregate classifications are made principally for the purpose of easier identification of particular aggregate lots or to become familiar with the different types of aggregates .There are numerous ways of classifying aggregates. These classifications are made according to source of aggregate, specific gravity or unit weight of aggregate, size of aggregate particles, shape of aggregates, surface texture of aggregates, mode of preparation of aggregates, geological origin of aggregates, and mineral composition of aggregates and reactivity of aggregates . Aggregates are not generally classified by mineralogy ; the simplest and most useful classifications are on the basis of source and specific gravity .

D. *Fine Aggregate*

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.60. Locally available river sand conforming to grading zone I of IS:383-1970. Clean and dry river sand available locally will be used . Sand passing through IS 4.75mm sieve will be used for casting all the specimens . Fine aggregates is defined as material that will pass a No.4 sieve and will, for the most part, be retained on a No. 200 sieve. For increased workability and for economy as reflected by use of less cement, the fine aggregates should have a rounded shape . The purpose of the fine aggregate is to fill the voids in the coarse aggregates and to act as a workability agent.

E. *Water*

Water is a key ingredient in the manufacture of concrete . It is also material on its own right . Understanding its properties is helpful in gaining and understanding of its effects on concrete and other building materials. Although water is an important ingredient of concrete little needs to be written about water quality , since it has little to do with the quality of the concrete . However mixing water can cause problems by introducing impurities that have detrimental effects on concrete quality . Although satisfactory strength development is of primary concern, impurities contained in the mix water may also affect setting times, drying shrinkage , or durability , or they may cause efflorescence . The water used for experiments was potable water. It should be free from organic matter and the pH value should be between 6 to 7.

IV. *BOTTOM ASH*

Bottom ash is agglomerated ash particals, formed in pulverized coal furnaces that are too large to be carried in the flue gases and impinge on the furnaces walls or fall through open grates to an ash hopper at the bottom of the furnace. Physically, bottom ash is typically grey to black in color, is quite angular. Bottom ash is coarse, with grain sizes spanning from fine sand to fine gravel. Bottom ash can be used as a replacement for fine aggregate and is usually sufficiently well graded in size to avoid the need for blending with other fine aggregates to meet gradation requirements. The use of bottom ash in normal strength concrete is a new dimension in concrete mix design and if applied on large scale would revolutionize the construction industry, by economizing the construction cost and decreasing the ash content.

4.1 COARSE AGGREGATE

Table 3.1 Physical properties of coarse aggregate

PROPERTY	EXPERIMENTAL VALUE
Specific gravity	2.64
Fineness	3.14
Impact strength	6.38
Crushing strength	2.90
Water absorption	0.98

4.2 CEMENT

Table 4.2 Physical properties of cement

PROPERTY	EXPERIMENTAL VALUE	PERMISSIBLE LIMIT AS PER IS 12269-1987
Normal consistency	32%	-
Specific gravity	3.12	Not less than 1.5
Initial setting time	70 min	Not less than 30 min
Final setting time	245 min	Not more than 600 min
Fineness (by sieving) %	3.5%	Not more than 10%

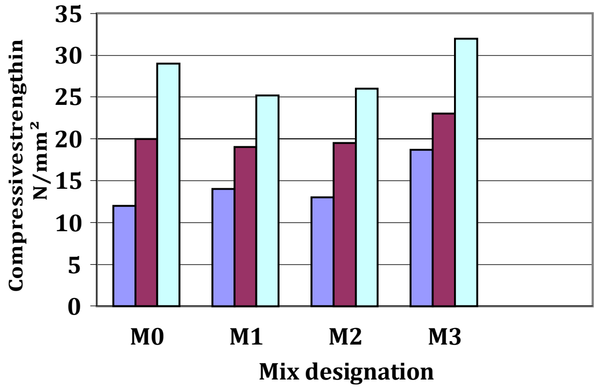
V. *RESULTS AND DISCUSSION*

5.1 COMPRESSIVE STRENGTH TEST

A total of 42 cubes of size 150 x 150 x 150mm were casted and tested for 7, 14 days and 28 days testing each of specimens after conducting the workability tests. The results are tabulated below:

Table 5.1 Test results for compressive strength test

MIX DESIGNATION	FINE AGGREGATE REPLACEMENT % (BOTTOM ASH)	COMPRESSIVE STRENGTH OF CONCRETE (N/MM^2)		
		7days	14 days	28days
M0	0	12	20	26
M1	10	14	17	22
M2	20	18	24	28
M3	30	10	12	20

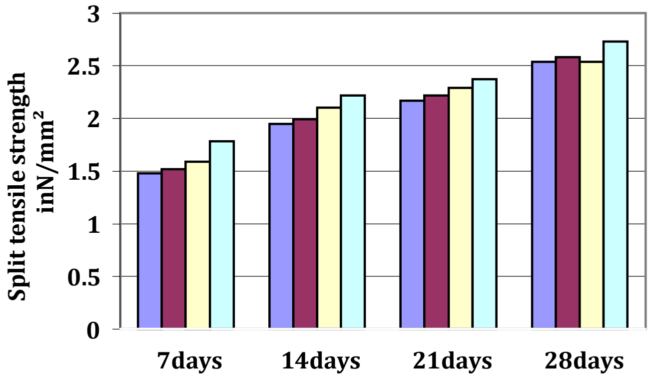


5.2 SPLIT TENSILE STRENGTH TEST

The split tensile strength obtained by testing the cylindrical specimen for M_{25} grade of concrete to all the mixes designed for various replacements are given below:

Table 5.2 Test results for split tensile test

Mix Designation	*Fine Aggregate Replacement % (bottom ash)*	*in N/mm2*		
		7days	*14days*	*28days*
M0	***0***	***1.48***	***1.95***	***2.54***
M1	***10***	***1.52***	***1.99***	***2.58***
M2	***20***	***1.88***	***2.07***	***2.82***
M3	***30***	***1.23***	***1.73***	***2.23***



5.3 FLEXURAL STRENGTH TEST

The flexural test was conducted for M1 mix only since it has the highest compressive and split tensile strength to compare it with conventional i.e. M0. A Total of 5 beams were casted and tested as follows:

Table 5.3 Test results for Flexural Strength Test

MIX DESIGNATION	*FINE AGGREGATE REPLACEMENT % (BOTTOM ASH)*	*FLEXURAL STRENGTH IN N/MM²*	
		7days	*28days*
M0	*0*	*2.66*	*4.7*
M1	*10*	*2.43*	*4.56*
M2	*20*	*3.34*	*6.03*
M3	*30*	*3.12*	*4*

5.4 ACID TEST (HYDROCHLORIC ACID):

Tests were carried put according to ASTM G20-8 to obtain weight loss of different type of concrete. Acid test results are shown in table and from result it will be observed that 30 days. Hydrochloric acid to the concrete with various proportion of bottom ash. The acid attack variation with respect to the percentage of replacement concrete are shown in table.

Table 5.4 Test results of acid attack after 28 days (weight)

MIX DESIGNATI O N	*FINE AGGREGAT E REPLACEMENT % (BOTTOM ASH)*	*BEFORE ACID ATTACK (KG)*	*AFTER ACID ATTACK (KG)*	*LOS S IN N/MM²*	*STRENGTH % LOS S*
M0	*0*	*29*	*28.45*	*0.55*	*1.89*
M1	*10*	*25.20*	*24.26*	*0.94*	*3.37*
M2	*20*	*26*	*25.32*	*0.38*	*1.42*
M3	*30*	*28*	*27.66*	*0.64*	*2.30*

5.5 RAPID CHLORIDE PERMEABILITY TEST:

The chloride permeability of bottom ash concrete is higher than that of control concrete. The permeation of chloride ions into the bottom ash concrete decreseas drastically when a low dosage of superplasticizers is used (ghafoori et al., 1996). In this research also, chloride ion penetration increases with increase in superplasticizers dosage. Kou shi- Cong et al., 2009 demonstrated that at the same W/C ratio the resistence to chloride- ion penetration of the concrete mixes decreased with increasing percentages FBA replacement of river sand. In this study also resistance to chloride- ion penetration to the concrete mixes when replacement of sand by bottom ash increases.

Table 5.5 Rapid Chloride Test

MIX RATIO	*HP%*	*ELECTRIC CHARGE (COULOMB)*
BA 0	*0.8*	*1640*
BA 10	*1*	*1855*
BA 20	*1.2*	*2493*
BA 30	*1.6*	*3393*

IV. Conclusions

Bottom ash can be used to replace some of the fine aggregate in a concrete mixture. A study on properties of concrete made with fine aggregate by BA in different proportions can be investigated to enhance the concrete properties and also to reduce the pollution or waste generation from factories. The workability of concrete increases with the increase in BA replacement. The properties of concrete increased gradually with the increase in BA 20% replacement later it is decreased gradually. The partial replacement of sand by BA upto 20% of concrete produced a better concrete in terms of compressive strength, split tensile strength and flexural strength than the other mixes. The strength gaining of beam is gradually increasing. The strength variation for three grades is in increasing manner. The flexural strength of conventional varies as 8.50%,9.11%,10.9% of increment at 7, 14 and 28 days respectively for M2 mix. Even though we are not comparing with the conventional concrete but the attainment of strength for is satisfactory. The chloride ion penetration was almost under moderate condition up to BA 30 concrete. The expansion of bottom ash concrete when subjected to alkaline attack was more than that control concrete at all replacements.

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