International Journal of Emerging Engineering Research and Technology
Volume 3, Issue 6, June 2015, PP 114-121
ISSN 2349-4395 (Print) & ISSN 2349-4409 (Online)

A Study on Mechanical Properties of Latex Modified High Strength Concrete Using Bottom Ash as a Replacement for Fine Aggregate

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ABSTRACT

Concrete is the most important engineering material. It is a mixture of cement, fine aggregate and coarse aggregate. River sand is the main raw material used as fine aggregate in the production of concrete. The natural sources of river sand are getting depleted gradually, therefore, in the present circumstances of scant sources of river sand; it becomes essential and more significant to find out its substitute material in concrete. In this research paper an attempt has been carried out to investigate the possibility of utilizing bottom ash as a replacement material for fine aggregate in the production of high strength concrete with latex as an additive and various strength properties were tested. The strength development for varies percentages (0-50%) replacement of fine aggregate with 10% of bottom ash can easily be equated to the strength development of latex modified high strength concrete at varies ages. The compressive strength of bottom ash concrete at the curing age of 28 days was increased compared to control concrete. Splitting tensile strength of concrete improved at percentages of replacement of bottom ash.

Keywords: Bottom Ash, Metkaolin, Natural Rubber latex and High strength concrete.

INTRODUCTION

Concrete

Concrete is one of the most widely used materials throughout the world in the various fields. Cement, sand, crushed quarry stones and water are generally used as ingredients of concrete. Sand and crushed quarry stones are available naturally and locally. River sand is the main raw material used as fine aggregate in the production of concrete. As the natural sources of river sand are getting depleted gradually, it becomes essential and more significant to find out substitute material in concrete. At the same time the challenge for the civil engineers in the future is to understand the project with the concept of sustainable development and this involves the use of high performance materials and products should be manufactured at reasonable cost with least impact on the environment.

In India, nearly 70% of electricity generated is by combustion of fossil fuels, out of which nearly 61% is produced by coal-fired plants. This results in the huge production of ash. This ash is disposed either in dry or wet open area available near the plant or by grounding both bottom ash and fly ash or mixing it with water and pumping into artificial lagoon or dumping yards. Due to huge disposal of fly ash and bottom ash, it is adversely polluting water bodies and productive land.

The use of coal ash in high strength concrete is a new dimension in concrete mix design. Due to replacement of bottom ash with fine aggregate economizes the construction cost and decreases the ash content. Bottom ash is a by- product which is obtained by burning coal at thermal power plants.

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Bottom ash particles are coarser than fly ash .It is a coarse, porous and angular similar to sand sized. Particle size distribution of bottom ash is similar to that of fine aggregate; hence it can be used as substitute for naturally available sand up to 10% with metkaolin as a mineral admixture to develop higher range strength in concrete.

High Strength Concrete

Concrete whose strength is at least 40 MPa is said to be a high strength concrete. High strength concrete is a concrete which is engineered to satisfy the criteria supposed to overcome the limitation of normal strength concrete in order to meet the requirements specific to its intended use. The requirements may involve enhancement of characteristics such as placement and compaction without segregation, long term mechanical properties, early age strength and service life in severe environments. If the high strength concrete is used in the compression member it inturn reduces the size of the member. Thus the structure becomes economical. The strength of the high strength concrete made by mixing supplementary cementing material those having pozzolanic property; it fills in between the cement pores, reduces the pores and improves the strength. Generally mineral admixture is finer than the cement.

TEST ON INGREDIENT MATERIALS

Properties of Ingredients Materials

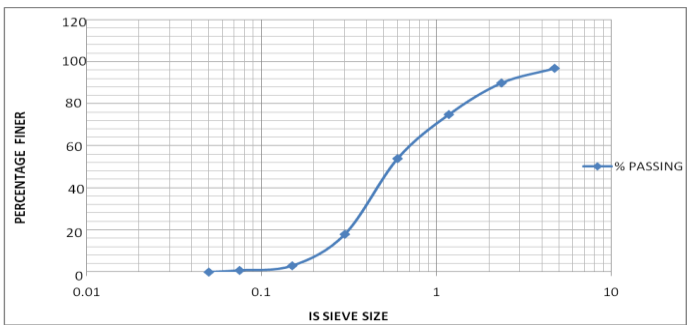
Strength of concrete mainly depends upon the properties of the ingredients that are used in the concrete. Properties of ingredient materials are as follows.

Tests on Cement

Chettinad-OPC 43 grade was used throughout the experiment. The cement was tested according to IS standard conforming to IS 8112-1989 to determine its various physical properties. Cement is used for binding and strength parameter of the concrete. The overall quality of cement required for the investigation was procured in the single lot which is stored in the appropriate manner. Test results obtained are satisfactory and are well within the range.

Tests on Fine Aggregate

Locally available river sand confirming to zone II as per IS 383-1970 was used for the work. This is used as a filler material in the concrete. The particle size distribution is shown in graph 1.



Graph1. *Sieve analysis of fine aggregate*

Test on Coarse Aggregate

Quarried and crushed granites stone were used as coarse aggregates. The specific gravity of coarse aggregates of 16mm and downsize was found according to the norms of Indian standards.

Water

Water which is fit for drinking is generally considered fit for making concrete. Water should be free from oils, acids, alkalis, and other organic Impurities. Water performs two functions in a concrete

mix. Firstly, it reacts with the cement to form a cement paste in which the inert aggregates are held in suspension until the cement paste has hardened. Secondly, it serves as a lubricant in the mixture of fine aggregates and cement.

Natural Rubber Latex

The Natural Rubber latex is collected from Sullia, Dakshina Kannada District, Karnataka, India and Properties are summarized in the table 1. The latex modified concrete is defined as Portland cement and aggregate combined at the time of mixing with organic polymer that is dispersed in water. This dispersion is called as latex. Inclusion of Natural rubber latex improves the binding properties and adhesion with aggregates. This provides superior compressive strength to the concrete. In addition they provide good adhesion to other material as well as resistance to physical damage such as abrasion, erosion, impact and chemical attack. When the performance of concrete is substantially higher than that of normal type concrete, such concrete is regarded as High Performance Concrete.

Table1. *Properties of Natural Rubber Latex*

Sl.No	Property	Rubber latex
1	Color	White
2	Total Solid Content (% By Weight)	61.5 Max
3	Dry Rubber Content (% By Weight)	60 Min
4	Non Rubber solid content	1.50 Max
5	K(OH) Number	0.55 Max
6	Ammonia content , NH3 %	0.70 Max
7	Mechanical stability time	600 TO 1200
8	Volatile Fatty Acid Number	0.10 Max
9	Magnesium Content	8
10	pH	10.4 Min
11	Coagulum Content , % By Mass	0.01 Max
12	Sludge Content, % By Mass	0.01 Max
13	Copper content As PPM	5
14	Iron content As ppm	8
15	Particle size of Rubber latex	0.2µm.
16	Specific Gravity of Rubber latex	0.94

Bottom Ash

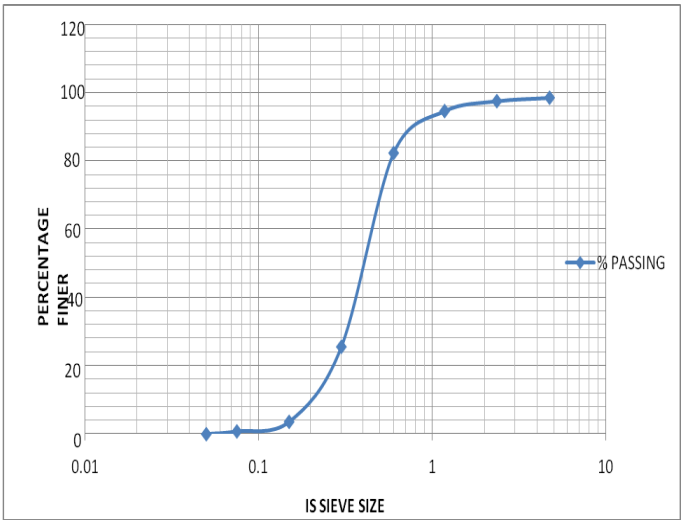
In this study, bottom ash is obtained from UPCL thermal power plant Udupi, Karnataka, India. Basically, the UPCL thermal power plant comprises of 2 power-generating units, each with a nominal net capacity of 600MW. The type and origin of coal burned, boilers type, degree of pulverization, firing conditions in the furnace and ash handling practices will affects the characteristics on physical, mechanical and chemical of bottom ash. Bottom ash is a coarse material having grains similar to or slightly bigger than that of sand. Bottom ash is a coal combustion residues from pulverized thermal power stations have been considered as solid garbage. But coal combustion residue is increasing in alarming rate and being regarded as a useful substitute material resource.

Table2. *Constituents of Bottom ash*

Sl.No	Name of constituents	In %(mass/volume)
1	Silica (SiO_2)	48.71
2	Aluminium Oxide (Al_2O_3)	29.23
3	Titanium Oxide (TiO_2)	1.88
4	Iron Oxide (Fe_2O_3)	4.29
5	Calcium Oxide (CaO)	7.44
6	Magnesium Oxide (MgO)	1.70
7	Sodium Oxide (Na_2O)	1.16
8	Potassium Oxide (K_2O)	0.55
9	Sulphur trioxide (SO_3)	3.96
10	Phosphorous Oxide (P_2O_5)	0.22

Table3. *Results of Sieve Analysis for Bottom ash*

IS Sieve Size	Cumulative percentage passing
4.75mm	98.6
2.36mm	97.6
1.18mm	94.7
600 micron	82.4
300 micron	25.6
150 micron	3.6
75 micron	0.8
<75 micron	0



Graph2. *Sieve analysis of bottom ash*

Metakaolin

Metakaolin is refined kaolin clay that is fired (calcined) under carefully controlled conditions to create an amorphous aluminosilicate that is reactive in concrete. Like other pozzolans, Metkaolin reacts with the calcium hydroxide (lime) byproducts produced during cement hydration. Metkaolin procured from the ASTRA chemicals, Chennai. Metakaoline combines with the calcium hydroxide to produce additional cementing compounds also it helps in holding concrete together. As met kaolin is very fine and highly reactive it gives fresh concrete a creamy, non stick texture that makes finishing easier. Metkaolin reduces the efflorescence's which is caused when calcium hydroxide reacts with carbon dioxide in the atmosphere.

Table4. *Properties of metkaolin*

Specific Gravity	2.40 to 2.60
Physical Form	Powder
`Color	Off white, Gray to Buff
Specific Surface	8 – 15 m2/g

Super-Plasticizer

Conplast- SP430 is a super plasticizing slump retaining admixture procured from Fosroc constructive solution. Conplast SP430 is used where a high degree of workability and its retention are required; where delays in transportation or placing are likely or when high ambient temperatures cause rapid slump loss. It facilitates production of high quality concrete. There is no particular methods are available to adopt the percentage of super plasticizer, since the Optimum percentage of the super-plasticizer are calculated by trial and error method. Properties of Conplast SP430 are tabulated in the below table 5.

Table5. *Properties of Conplast SP430*

1	Specific gravity	1.20 to 1.22 at 300C
2	Chloride content	Nil. as per IS:9103-1999 and BS:5075
3	Air entrainment	Approx. 1% additional air over control

EXPERIMENTAL PROGRAM

The experimental program me consisted of preparing M70 concrete design as per ACI method and its mix ratio was found to be 1:0.94:1.288.

TEST SPECIMENS AND TEST PROCEDURE

Specimens were casted to check the hardened properties of concrete. The ingredients of concrete were in dry state and thoroughly mixed in mixer machine till uniform consistency was achieved and filled in the mould. Cubes were kept in vibrating table to compact. After compaction the specimens were leveled and the specimens were demolded after 48 hours from the time of addition of water to the ingredients of casting. Then the specimens were immersed in water for curing. In this experimental work total of 216 concrete specimens were casted with 108 cubes and 108 cylinders. The bottom ash is added along with fine aggregate and Natural Rubber Latex (NRL) is added along with water. At the age of testing, specimens were taken out from the water, dried and then tested.

RESULTS AND DISCUSSIONS

The test conducted for high strength concrete with natural rubber latex as an additive and adding bottom ash as a replacement for fine aggregate.

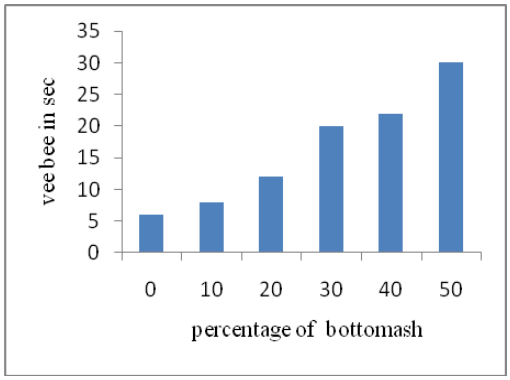
Fresh Properties

Table6. *Values obtained from the compaction factor*

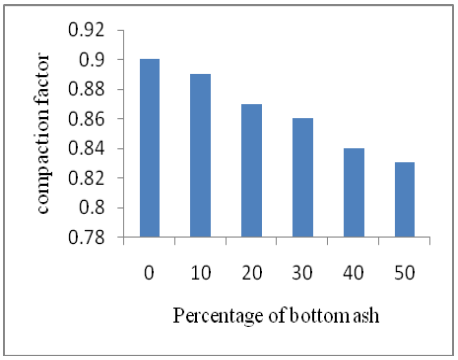
Sl no	Grade of concrete	bottom ash for in %	Compaction factor
	M 70	0	0.9
2		10	0.89
3		20	0.87
4		30	0.86
5		40	0.84
6		50	0.83

Table7. *Values obtained from Vee Bee test*

Sl no	Grade of concrete	bottom ash in %	Vee bee time in sec
1	M 70	0	6
2		10	8
3		20	12
4		30	20
5		40	22
6		50	30



Graph3. *Compaction factor value*



Graph4. *Vee Bee seconds*

Compaction factor value decreased when bottom ash was added to the concrete as replacement for fine aggregate, Results are tabulated in table 6 and graphical representation is shown in graph3.

Vee bee test conducted for bottom ash added high strength concrete; Vee bee time decreased as the percentage of bottom ash increased and result shown in table 7.

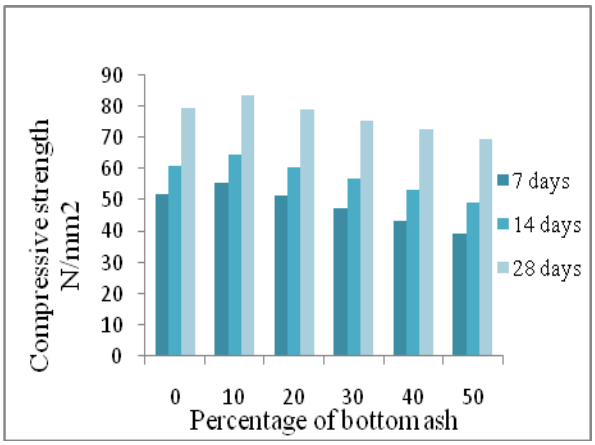
Hardens Properties

Table8. *Compression strength of concrete*

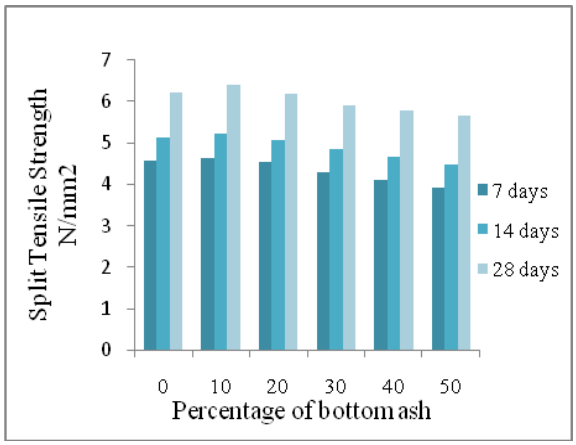
Sl no	Percentage of bottom ash	Compression strength in N/mm^2		
		7 days	14 days	28 days
1	0	51.95	61.24	79.82
2	10	55.41	64.86	83.76
3	20	51.38	60.66	79.21
4	30	47.63	56.94	75.57
5	40	43.59	53.30	72.72
6	50	39.28	49.46	69.82

Table9. *Splitting tensile strength of concrete*

Sl no	Percentage of bottom ash	Splitting tensile strength in N/mm^2		
		7 days	14 days	28 days
1	0	4.58	5.13	6.23
2	10	4.63	5.22	6.41
3	20	4.53	5.08	6.19
4	30	4.3	4.84	5.92
5	40	4.12	4.68	5.79
6	50	3.91	4.49	5.67



Graph5. *Compressive strength*



Graph6. *Split tensile strength*

Compressive Strength

The Compressive strength of concrete mixes made with various percentages of bottom ash as replacement to fine aggregate, natural rubber latex used as an additive and test conducted at the ages of 7, 14 and 28 days. The test results are shown in table 8 and it was observed that the compressive strength of concrete increases up to 10% replacement of bottom ash for fine aggregate and strength decreases with the increase in percentage of bottom ash.

Split Tensile Strength

The splitting tensile strength of concrete mixes made with various percentages of bottom ash as replacement to fine aggregate, natural rubber latex used as an additive and test conducted at the ages of 7, 14 and 28 days. The test results are shown in table 9 and it was observed that the split tensile

strength of concrete increases up to 10% replacement of bottom ash with fine aggregate and strength decreases in the increasing percentage of bottom ash.

CONCLUSION

Following conclusions were drawn from this research work

- The workability of concrete decreased on use of bottom ash as partial replacement for fine aggregate.
- For latex modified high strength concrete, compressive strength of concrete increases up to 10% replacement of fine aggregate with bottom ash.
- For latex modified high strength concrete, split tensile strength of concrete increases up to 10% replacement of fine aggregate with bottom ash.
- Compressive strength and split tensile strength of fine aggregate replaced bottom ash concrete to increase with age for all the percentage replacements.
- Fine aggregate can be replaced by bottom ash up to 10% for latex modified high strength concrete.
- The use of bottom ash in concrete is commended as an alternative to fine aggregates in concrete.

REFERENCES

[1]. Andrade L.B., J.C. Rocha, M. Cheriaf (2009), "Influence of coal bottom ash as fine aggregate on fresh properties of concrete", Construction and Building Materials, Vol. 23,pp 609-614.

[2]. Aggarwal P. , Aggarwal Y, Gupt S.M.(2007*), "*Effect of bottom ash as replacement of fine aggregates in concrete",Asian journal of civil engineering (building and housing),Vol. 8, no. 1 Pages 49-62.

[3]. B. B. Patilet. al :"Strength and Durability Properties of High Performance Concrete incorporating High Reactivity Metakaolin" Vol.2,Issue.3, May-June 2012 pp-1099-1104.

[4]. B.L.Gambhir "concrete Technology" 4th Edition published by the Tata Mc Graw Hill Education private limited.

[5]. Elizabeth Chong Eu Me "effect of polymer on compressive strength and total porosity of concrete".

[6]. H.Sudarsana Rao, K.Munirathnam, Vaishali. G.Ghorpade, and C.Sashidhar "Influence of Natural Rubber Latex on Permeability Of Fibre Reinforced High-Performance Concrete", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 2, Issue 7, July 2013.

[7]. IS: 8112-1989. Specification for 43grade ordinary Portland cement. Bureau of Indian standards, New Delhi.

[8]. Vinaya. K. L and Sanjith. J, "Effect of Natural Rubber Latex on Normal Strength Concrete and High Strength Concrete" "National 2nd national conference on futuristic technology in civil engineering for sustainable development-NCFTC 2014, 10th may 2014, SJBIT, Bengaluru".

[9]. Vikas R Nadig and Sanjith. J, "Bottom ash as partial sand replacement in concrete " IOSR journal of mechanical and civil engineering, Vol.12, Issue 2, March-April 2015.

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