SUSTAINABILITY OF USING BOTTOM ASH TO SAVE NATURAL RIVER BED SAND

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ABSTRACT. Concrete is the universal largest consumable construction material after water and needs a very huge amount of ingredients for making concrete. River bed sand is the almost commonly and traditionally used as fine aggregate (ingredient) for concrete in many parts of the world. A stage has now been reached where inspires researchers to take up focus on alternative materials to replace the natural sand. The substitution of raw materials with alternatives is an important eco efficiency driver. Even though the mortar makes up as minor as 7% to 8% of the total volume of a masonry wall and fine aggregate take about 85% of mortar volume, it plays a crucial role in the performance of a structural units. Therefore it is necessary to understand the behavior of mortar when as substitute alternative material like bottom ash or fly ash is used as replacement to sand from partially to fully. On the other hand, enormous quantity of coal ash (fly ash, Bottom ash and pond ash) is being produced every day in Thermal Power Station which led down to many environmental problems. If thermal power plant coal product ash utilized as a part of sand then it to make up for the scarcity of sand challenged by concrete users. In the present investigation bottom ash is used as fine aggregate in cement mortar for 5 different grades CM1:2, CM1:3, CM1:4, CM1:6, and CM1:8. The study to obtain Bottom Ash Replaced Cement Mortar (BRCM)s, their behaviors with to Normal Cement Mortar (NCM: zero replacement level of bottom ash) are presented. The effect of incorporating bottom ash as fine aggregates (FA) partially and fully on the properties of mortar in fresh state are assessed and discussed.

Keywords: River bed sand, Mortar, Alternative material, Bottom ash, NCM.

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INTRODUCTION

There is a huge demand for materials in the concrete sector due to the fast growing needs of infrastructure. Concrete as a construction material has great prospective all over the world and its use is next only to that of usable water. Aggregates contribute to about three fourth of concrete mass and hence there exists a great requirement for them. The speedy and enormous infrastructural developments in India demand massive quantity of natural sand for concrete, as fine aggregate. India is still the third fastest upward major economy in the world. This booming economy has jerk started all industry sectors as well as the construction & infrastructure industry, which demands for additional 1.08 x 10^5 MW power generation to meet the budding economy needs. India almost depends on thermal power as its main source (approximately 85%) and coal has been the main source of energy for the production of power, as it is one of the cheapest sources of fuel as compare to other one. Huge quantity of coal ash generated from Thermal Power station and if this ash product utilized to make up the scarcity of sand problem then the possibility to be develop for sustain concrete sustainable future.

Thermal power plant generated ash has divided into two categories, i.e. fly ash and bottom ash. This ash majorly constitutes fly ash about 80% and remaining twenty percent of total ash produced is dry bottom ash. Bottom ash is looking like a dark gray, granular, porous, material that is catcher in a water-filled hopper at the bottom part of the furnace. Fly ash has been accepted to for recycled alternative material to cement and other applications at universal level, while the bottom ash has not been recognized as compare to fly ash and has been disposed of using wet system in whole. More than 630 x 10^6 m^3 water is required per annum for the disposal of bottom ash in slurry form. The thermal power plants in India generate fly ash as predictable 100 million tones/ annum, C-FARM report 2012 [11]. The World Bank has now cautioned to India that by 2015, disposal of coal ash would require 1000 square kilometres land.

The physical, chemical and morphological properties of bottom ash depend on numerous factors such as source and category of coal used, temperature at which coal is burnt, disposal technique of ash, its storage etc., Ranganath R V 1998 [9]. To concern with strength and durability, pond ash properties is important and necessary as it play role of constituent of concrete. Therefore in the present investigation, it was determined to collect bottom ash from minimum two different sources to look out the extent of variation in the properties of bottom ash from source to source and exercise it as a constituent in mortar, concrete. However a many researcher doing research has been carried out for the effective utilization of fly ash but literature available on bottom ash utilization as an element material for concrete in construction industry is not momentous.

The researcher facts are not satisfactory as the shape of bottom ash not uniform from places of origin (of the coal used), and physical, chemical properties of bottom ash. Ranganath 1999 [10]; Krishnamoorty et. al. 1994 [5] investigated the flow of mortar and workability of cement concrete for fine aggregate replacement with bottom fly ash upto 30% and It was stated that fly ash with bottom ash results in a more fruitful material to be used as fine aggregate relatively than as cement replacement.

Dhir et al. 2006 [3] examining the role of cement content in particularly the influences of aggregate characteristics in concrete and are considered the cement and water contents the associated mix adjustments for maintaining sustainable concrete. Ghafoori et. al. 1996 [4] considered fresh and hardened properties of bottom ash concrete for betterment of choosing comparative fine aggregate. It was accomplished that the mixing water requirement increased when bottom ash is used in concrete. Yuksel et. al. 2007 [12] reported about the workability of concrete mixtures replacement percentage from 10% to 40% of bottom ash as fine aggregate replacement for binder content of concrete 350 kg/m3.

Andrade et. al. 2009 [1] investigated "Influence of coal bottom ash use on fresh properties of concrete at the fresh state. Kim et. al. 2011 [6] suggested that the slump flow values of fresh concrete remain constant with the increased replacement ratio of fine bottom ash. The effect of bottom ash as fine aggregate replacements partial to full level in concrete compressive strength decreases at fixed w/c ratio Bai et. al. 2005 [2] but according to Kurama et. al. 2008 [7] compressive strength improved with increase in amount of bottom ash concrete. Mahajan and Bhgat 2016 [8] reported the effect of bottom ash as partial replacement of cement in concrete and observed that compressive strength increased with increase in amount of bottom ash concrete when compared to control concrete. The bottom ash has little higher water absorption ratio as compared of natural river sand

Profitable results will encourage large scale utilization of bottom ash in construction industry which gives basically the following benefits: a) saves rapid depleting natural resource like fine aggregate, so as to add to sustainable construction. b) Large scale utilization of industrial waste material. c) facilitates environmental and ecological benefits and d) helps to conserve the precious land available.

MATERIAL CHARACTERISATION AND MIX PROPORTIONING

The present research deals with the materials used in this research work. The work accomplish on check out the properties of materials used in the present experimental work is presented in this chapter. The characterizations, as per applicable codes of practices were used for making the Mortar and Concrete material.

Water

Fresh potable tap water which satisfying the requirements according to IS 456 -2000 is used for preparing mortar, concrete.

Cement

As per conforming to IS: 12269-2004, Bureau of Indian Standard, New Delhi the cement were taken for experimental study. To achieve the desired strength levels, medium strength cement having 28-day strength of 53MPa was used. Ordinary Portland cements (OPC) of (Trade name) Chettinad Cement Corporation Private Limited with 53 grades conforming to IS: 269-1976 has been used throughout the testing in this study. The chemical and physical properties characteristics of cement as determined and physical properties are given in table 1.

Table 1 Physical Characteristics of Cement

Sr. No	PARTICULAR	53 GRADE OPC USED	REQUIREMENT AS PER IS : 12269 : 1987
1	Standard consistency (%)	33 (as per IS:4031 Part 4:1988)	27-35
2	Fineness by Blaine's method (m2/kg) Percent retained on 75 µby wet sieving (%) Percent retained on 45 µby wet sieving (%) BET surface area (m2/kg)	 320 5 30 1488	 Not less than 225 - - -
3	Mean particle dia (µm) by Laser based Time of Transition method.	22	-
4	Setting time (minutes) Initial Setting Time (IST) Final Setting Time (FST)	 240 330	 Not less than 30 Not more than 600
5	Soundness by (Le-chatelier method (mm))	0.75	Not more than 10
6	Specific Gravity	3.15	-
7	Compressive Strength (MPa) 3days: 72 (+/-) 1 Hrs 7days: 168 (+/-) 2 Hrs 28days: 672 (+/-) 4 Hrs	 37.01 44.02 60.89	 Not less than 27 Not less than 37 Not less than 53

Fine Aggregate

Natural river bed sand conforming to specification IS 2116 – 1980 having specific gravity 2.75 used as Fine Aggregate (FA). In addition to fine aggregate the bottom ash also used for partial replacement and Samples of bottom ash are collected from Eklahare Thermal Power Stations of Nashik and used as replacement for fine aggregate (sand).Some physical tests namely Loose Bulk Density (LBD), Rodded Bulk Density (RBD), Specific Gravity and Sieve analysis are carried out on the mixture of sand and bottom ash in different replacement levels and are given, see Figure 1. The effect of replacement of natural sand with bottom ash on specific gravity is shown in Figure 2.

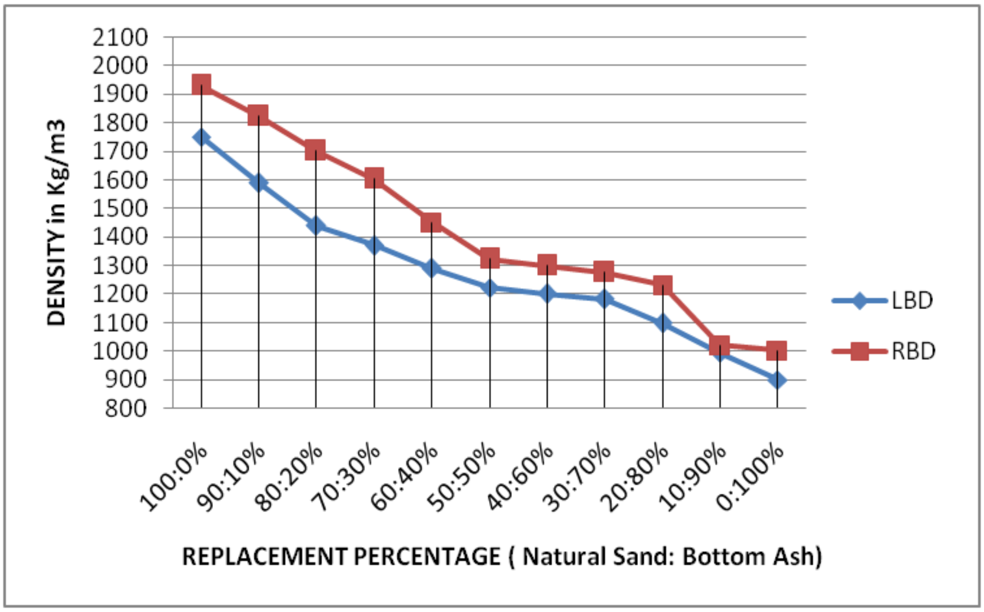

Figure 1   Effect of replacement of natural sand with bottom ash on LBD and RBD

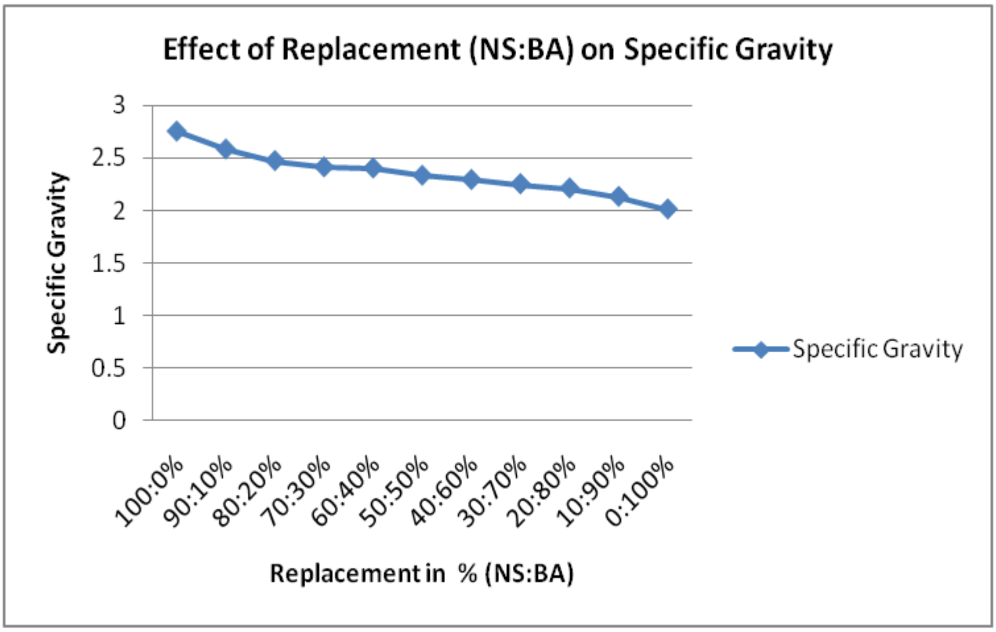

Figure 2   Effect of replacement of natural sand with bottom ash on specific gravity

EXPERIMENTAL PROGRAM

In the present study research work carried out on cement mortar mixes which incorporating bottom ash as fine aggregate. For the suitability of identifying and handling different

Table 2 Results of Flow Table Test for Cement (bottom ash) Mortar Mixes

MORTAR PROPORTION (CEMENT: FA)	MIX DESIGNATION	BOTTOM ASH REPLACEMENT (%)		MORTAR MIX (C:S:B)			W/C RATIO	W/C RATIO (CONSIDERING ABSORPTION OF WATER)	FLOW (%)
		Bottom Ash	Sand	C	S	B			
CM 1:2	CM2-B0	0	100	1	2	0	0.5	0.5	100
	CM2-B20	20	80	1	1.6	0.4		0.65	98
	CM2-B40	40	60	1	1.2	0.8		0.75	97
	CM2-B60	60	40	1	0.8	1.2		0.9	96
	CM2-B80	80	20	1	0.4	1.6		1.1	94
	CM2-100	100	0	1	0	2		1.35	93
CM 1:3	CM2-B0	0	100	1	3	0	0.6	0.6	100
	CM2-B20	20	80	1	2.4	0.6		0.8	99
	CM2-B40	40	60	1	1.8	1.2		1.1	98
	CM2-B60	60	40	1	1.2	1.8		1.3	98
	CM2-B80	80	20	1	0.6	2.4		1.45	95
	CM2-100	100	0	1	0	3		1.8	91
CM 1:4	CM4-B0	0	100	1	4	0	0.75	0.75	99
	CM4-B20	20	80	1	3.2	0.8		0.9	98
	CM4-B40	40	60	1	2.4	1.6		1.4	98
	CM4-B60	60	40	1	1.6	2.4		1.9	95
	CM4-B80	80	20	1	0.8	3.2		2	94
	CM4-100	100	0	1	0	4		2.2	90
CM 1:6	CM6-B0	0	100	1	6	0	0.85	0.8	98
	CM6-B20	20	80	1	4.8	1.2		1.5	96
	CM6-B40	40	60	1	3.6	2.4		1.9	93
	CM6-B60	60	40	1	2.4	3.6		2.45	93
	CM6-B80	80	20	1	1.2	4.8		3.3	91
	CM6-100	100	0	1	0	6		3.8	90
CM 1:8	CM8-B0	0	100	1	8	0	1.6	1.6	94
	CM8-B20	20	80	1	6.4	1.6		2	94
	CM8-B40	40	60	1	4.8	3.2		3	93
	CM8-B60	60	40	1	3.2	4.8		3.8	93
	CM8-B80	80	20	1	1.6	6.4		4.1	92
	CM8-100	100	0	1	0	8		5.5	90

Where, C: Cement, S: Sand, B: Bottom Ash proportion mixes, specimens are designated as CM2-B0, CM2-B20, CM2-B40, CM2-B60,CM2-B80, CM2-B100 for Mortar grade 1:2 and 0, 20, 40, 60, 80 and 100 represents replacement percentage of sand by bottom ash. The mortar mix proportions covers range 1:2, 1:3, 1:4, 1:6 and 1:8, which study for higher to lean mortar as per satisfying flow table test at extensive trials of w/c ratio. The study to obtain Bottom Ash Replaced Cement Mortar (BRCM)s, their behaviors with to Normal Cement Mortar (NCM: zero replacement level of bottom ash) are presented by conducting flow table test as per IS 2250-1981. During mixing process of BRCM mixes, it was essential to supplement additional water to the proposed mixes (in term of correction for water absorption of bottom ash) to get the required flow. The modified w/c ratio recorded in following table 2 for respective BRCMs. Table 3 shows the w/c ratio of BRCM and NCM related to water absorption of bottom ash and graphical representation of workability of BRCM mixes shown in Figure 3.

Table 3 w/c ratio of BRCM and NCM related to water absorption of bottom ash

MORTAR GRADE	W/C RATIO OF BRCM AT DIFFERENT REPLACEMENT LEVEL						NORMALIZED W/C RATIO OF BRCM (IN TERM OF 0% REPLACEMENT VALUE)					
	0%	20%	40%	60%	80%	100%	0%	20%	40%	60%	80%	100%
CM(1:2)	0.5	0.65	0.75	0.9	1.1	1.35	1	1.30	1.50	1.80	2.20	2.70
CM(1:3)	0.6	0.8	1.1	1.3	1.45	1.8	1	1.33	1.83	2.17	2.42	3.00
CM(1:4)	0.75	0.9	1.4	1.9	2	2.2	1	1.20	1.87	2.53	2.67	2.93
CM(1:6)	0.8	1.5	1.9	2.45	3.3	3.8	1	1.88	2.38	3.06	4.13	4.75
CM(1:8)	1.6	2	3	3.8	4.1	5.5	1	1.25	1.88	2.38	2.56	3.44

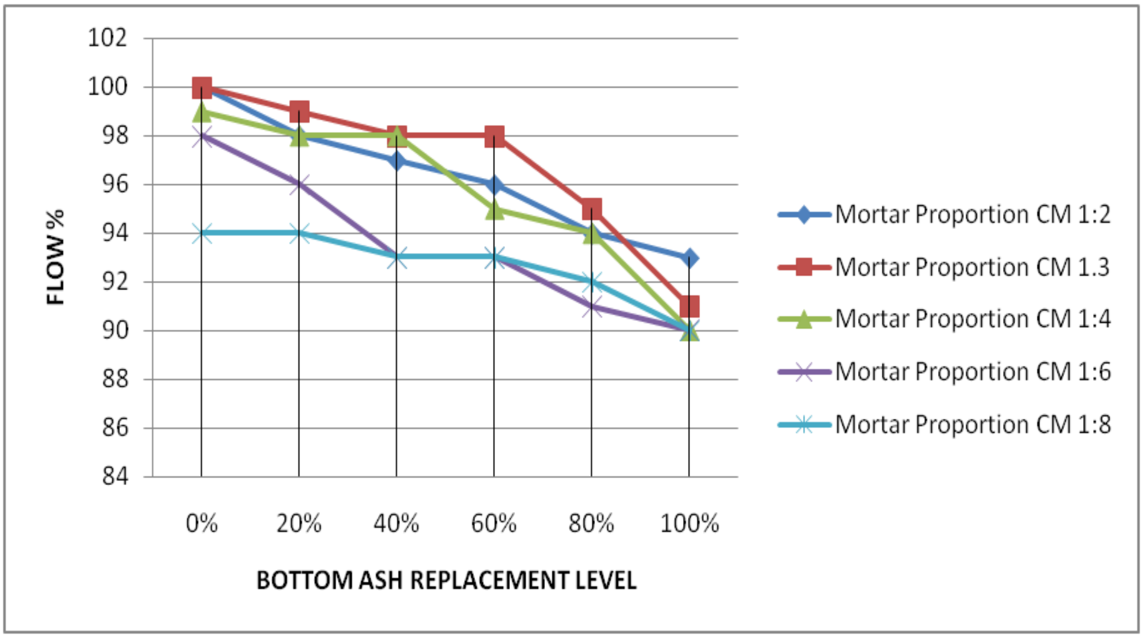

Figure 3 Workability of BRCM mixes

CONCLUDING REMARKS

From the results of workability of BRCM mixes at various percentage replacements and judge it with that of Normal Cement Mortar (NCM: zero replacement level of bottom ash), the following comments are made. All the BRCM mixes fulfilled the workability requirements in terms of flow test for different BRCM mixes ranging from 90% to 100%. However, it is observed that as the replacement percentage bottom ash increases, the workability in terms of flow regularly decreases due to richness of mortar. The BRCM mixes for superior grades of 1:2, 1:3 and 1:4 satisfied the percentage flow of 94 to 100 up to replacements of 60%. on the other hand remaining BRCM mixes have percentage flow ranging 90 – 100. As the replacement level of bottom ash increases, demand for water also proportionally increases. The tendency of bottom ash to absorbed water and required more water. The demand of water (or increased w/c ratio) is much more obvious for leaner grades of mortar as compare to higher grades of mortar because of the percentage of bottom ash content increases in leaner mortar mixes resulting in increased water capacity (fig.6.4). The second reason of increased water quantity is due to higher surface area occupied by bottom ash as it contains more particle content than natural river sand. Mortar mixes up to 60% replacement intensity are workable rewarding the flow requirement for all mixes other excluding CM1:8 which shaped slightly harsh mix

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