DEVELOPMENT OF A SUSTAINABLE AND COST EFFECTIVE PROCESS FOR FABRICATING GREEN HOLLOW BLOCK FROM INCINERATED BIOMEDICAL WASTE

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ABSTRACT

Waste generation has increased considerably worldwide in the last few decades. Solid wastes encompass the heterogeneous mass of throwaways from the urban community as well as the homogeneous accumulations of agricultural, industrial and mineral wastes. Waste generated from biomedical activities represents a real problem of living nature and human world. A proper waste management system should be required to dispose hazardous biomedical waste and incineration should be the best available technology to reduce the volume of this hazardous waste. The incineration process destroys pathogens and reduces the waste volume and weight but leaves a solid material called biomedical waste incineration ash as residue which increases the levels of heavy metals, inorganic salts and organic compounds in the environment. Disposal of biomedical waste ash in landfill without proper treatment may cause contamination of groundwater due to leachate as metals are not destroyed during incineration. The limited space and the high cost for land disposal led to the development of recycling technologies and the reuse of ash in different systems. There is a scope of utilization of incinerated biomedical waste ash (IBWA) in the production of concrete.
This project deals with the experimental investigation of strength and durability properties of incinerated bio medical waste ash replacement of cement in various percentages (2.5, 5.0, 7.5, 10.0, and 12.5) in hollow block concrete and concrete

KEYWORDS: *Biomedical waste ash -strength and durability properties of hollow block concrete feasibility studies using BMWA – Future prospects.*

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1. Introduction

Biomedical waste ash produced from various medical resources such as hospitals, medical institutes and research centers caused great threat to the environment. Biomedical waste can be classified as hazardous and non hazardous. As per ministry of environment and forest of India, total biomedical waste produced is 4,05,702 kg per day, about 72% of the waste generated is treated where as the rest is left out untreated. Most common process for treatment of biomedical waste is incinerating in this process biomedical waste is incinerated in incinerators specifically made for biomedical waste .Biomedical waste is a collection of medical waste from diverse sources that pose a major risk to human, plant, or animal life now or in the future. It cannot be processed or discarded off without proper processing. Bio-medical waste is defined as "any solid and/or liquid waste, including its container and any intermediate product, generated during the diagnosis, treatment, or immunization of humans or animals, or related research activities, or in the manufacturing or testing of biological products in health camps". Biomedical waste is dangerous for two reasons. The first is infectivity, and the second is toxicity Biomedical waste is often burnt in incineration plants, yielding Incinerated Biomedical Waste Ash (IBMW) which is disposed off in landfills, which are not completely leak- proof. In India, presently biomedical waste is generating 550.9 tons per day, and it is annually increasing by 8%. Biomedical waste management is a basic public health concern and needs to planning for proper collection, safe storage, systematic transportation and disposal. The problem of biomedical waste management needs a safe technology, as also centralized facilities.Bio Human anatomical waste such as tissues, organs, and body parts, animal wastes generated during research from veterinary clinics, microbiology and biotechnology wastes, waste sharps such as hypodermic needles, syringes, scalpels, and broken glass are all examples of medical waste. discarded pharmaceuticals and cytotoxic drugs, soiled waste such as dressings, bandages, plaster casts, blood-contaminated material, tubes and catheters, and liquid waste from any diseased region Biomedical activities increase waste volume and have a substantial impact because it is mainly fatal. For the treatment and disposal of biological waste, an adequate waste management system is required. This biomedical waste ash will be used as partial replacement of cement in concrete manufacturing nowadays to improve the hardened properties of concrete.

2. Experimental Investigations

An experimental program was designed to produce a high strength concrete and hollow block with reduced cement content by biomedical waste ash. It comprises of casting of hollow block of size 385 X 210 X 150 ,Casting of cube size 150 X 150 X 150 mm for compressive strength, casting of cylinder of size 100mm diameter and 200mm height for split tensile strength. The materials used and the test methods are described in the following sections.

2.1 Materials used

Cement

Ordinary Portland cement of 53 grade conforming to IS: 12269 were used. The specific gravity of cement was found to be 3. 15.

Incinerated Bio medical waste ash (IBWA)

Biomedical waste ash which was used throughout this experiment was collected from medica care environmental centre sengipatti Thanjavur, which was grey in colour and lighter in weight and coarser than cement

Fine aggregate

Locally available river sand passing through 4. 75 mm sieve was used. The fineness modulus of fine aggregate was found to be 2. 43% and specific gravity was found as 2. 71.

Water

Fresh water available from local sources was used for mixing and curing of concrete.

Super plasticizer

To improve the workability of SIFCON, CONPLAST- 430, a high –range water reducing agent has been used.

2.2 Test program

2. 2. 1 Compressive strength test

The compressive strength of concrete is the most common performance measure in designing building and other structures. The compressive test on cubes was conducted on a computerized compressive testing machine of capacity 3000KN. The test was conducted on 100mm cube specimens.

2. 2. 2 Split tensile strength

The split tensile strength on cylinder was conducted on a computerized compressive testing machine of capacity 3000KN, the test specimens were placed between two plates.

2. 2. 3 Sorptivity test

Specimens of 100mm diameter and 50mm height for sorptivity test were prepared for each mixture. Measurements of capillary water absorption were carried out to determine the sorptivity coefficient of concrete specimens, which were preconditioned in oven at 100 ± 10^{0}C until a constant weight and then cooled down within dessicators 24 hr to achieve a constant moisture level. The specimens were covered on all the sides and the top surface with a suitable sealant to avoid evaporative effect and only the bottom surface is exposed for water by placing it in tray and rested on glass rods to allow the free access of water to the inflow surface. The water level in the tray was maintained at about 4-5mm above the base of the specimens during these experiments. Immediately after the immersion of specimen into water, the water absorption was measured at intervals of 1, 5, 10, 15, 20, 30, 60, 120, 180, 240, 300 and 360min. The sorption coefficient can be calculated by the following expression:

$$Q/A = k\sqrt{t}.$$

Where, Q=the amount of water absorbed in mm3; A=the cross section of the specimen that was in contact with water in mm2; t=time in seconds; t=the sorption coefficient of the specimen in mm/s1/2. The sorption coefficient was obtained from the slope of the linear relation between Q/A and √t.

Preparation of Test Specimens

Totally 90 specimens have been casted to study the hardened properties of Bio medical waste Ash Cement Concrete. Around 18 hollow blocks 385mm*210mm*150mm were casted for 28days the determination of compressive strength, 36 cubes of size 150mm*150mm*150mm and 36 cylinders of size 100mm*200mm and were casted for 7 days and 28 days, the determination of Compressive Strength, Splitting and Tensile Strength. As per IS: 10262, concrete of grade M20 has been designed with the mix proportion of 1:2.19:3.86.

3. Results and discussion

3.1 Compressive strength Test on hollow block concrete and cubes

Compressive strength test is carried out by compression testing machine (CTM) were conducted on cured cube specimen at 7and 28 days age using compression testing machine 3000kN capacity .The Concrete cubes and hollow blocks were fitted at center in compression testing machine and fixed to keep the cube in position. The load was then slowly applied to the tested cube until failure.

Compressive strength of hollow block size 385mm * 210mm * 150mm and compressive strength on concrete cube 150mm*150mm*150mm

Compressive strength (Mpa)=Compressive load /Area of cross section

Based on Compressive Strength (cube)

The test outcomes showed that, the percentage enhancement in compressive strength varies from -15.19 to 9.38% as compared to conventional concrete. The compressive strength of IBWA 7.5% mix improved as 9.38% more than conventional concrete cured at 28 days, it was found that IBWA 12.5 %-OPC 87.5% is having lower % of improvement as compared to other combinations.

TABLE 1: COMPRESSIVE STRENGTH OF CUBE

Mix Id	Average Compressive Strength (N/mm^2)		% Increase In Strength
	7 Days	28 Days	
OPC 100	12.1	21.03	-
IBWA 2.5-OPC97.5	12.26	22	4.50
IBWA 5-OPC 95	13.01	22.6	7.197
IBWA 7.5-OPC92.5	12.69	23.10	9.38
IBWA 10-OPC 90	9.92	19	-10.142
IBWA 12.5-OPC 87.5	8.56	18.06	-15.19

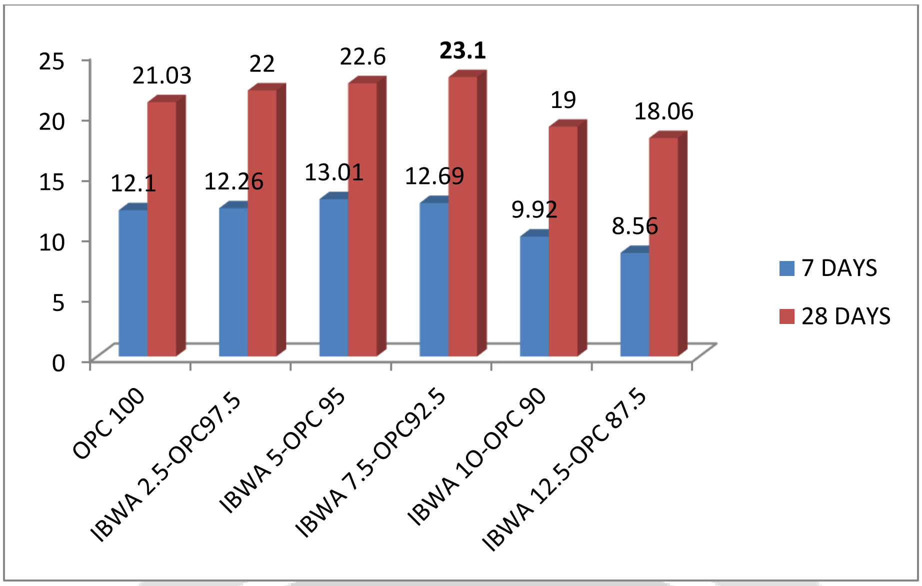


FIGURE 1: COMPRESSIVE STRENGTH OF CUBE

Based on Compressive Strength: (hollow block)

Compression strength of conventional at the age of 28 days curing is 7.4 Mpa compression strength varies from -6.9% to 15 % as compared to conventional concrete. The compressive strength of IBWA 7.5% mix improved as 15% more than conventional concrete cured on 28 days. it was found that IBWA 12.5% is having lower percentage.

TABLE 2: COMPRESSIVE STRENGTH OF HOLLOW BLOCK

Mix Id	28 Days of Avg. Compressive Strength (N/mm²)	% Increase In Strength
OPC 100	7.4	-
IBWA 2.5-OPC97.5	7.7	3.9
IBWA 5-OPC 95	8.1	9.0
IBWA 7.5-OPC92.5	8.6	15
IBWA 10-OPC 90	7.7	-3.9
IBWA 12.5-OPC 87.5	6.9	-6.9

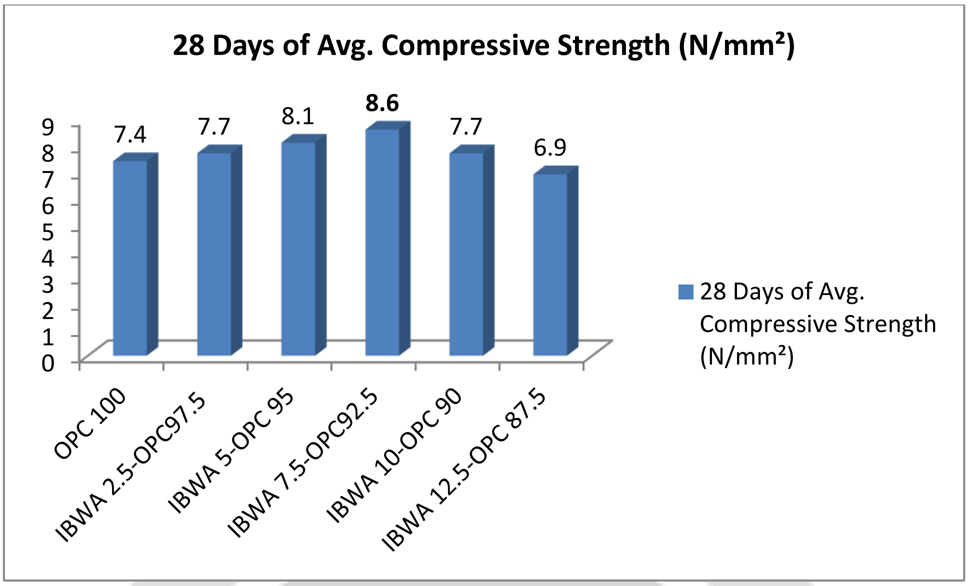


FIGURE 2 : COMPRESSIVE STRENGTH OF HOLLOW BLOCK

3.2 Splitting tensile strength Test

The splitting tensile strength test is performed on hardened concrete specimen to determine its tensile strength. Marginal variations in water to cement ratio, ingredient proportioning, increase in a slump, etc. impacts the desired mortar strength. This in turn affects the strength and stability of structures.
Quality tests are to be conducted on specimen at various stages starting from the production stage to the hardened stage, and on structures. Quality tests play an important role in ensuring the construction quality.
The testing machine should apply continuous load without shocks. So, for this test, two plates used. The dimension of the cylindrical specimen is 100 mm in diameter and 200 mm in height.

$$T=2p/\pi dl$$

TABLE 3: SPLITTING TENSILE STRENGTH OF CYLINDER

Mix Id	**Average split tensile Strength (N/mm^2)**		**% Increase In Strength**
	7 Days	**28 Days**	
OPC 100	0.84	1.89	-
IBWA 2.5-OPC 97.5	1.0	2.1	15.38
IBWA 5-OPC 95	1.37	2.5	32.6
IBWA 7.5-OPC 92	1.48	2.7	40
IBWA 10-OPC 90	1	2.2	20
IBWA12.5OPC87.5	0.73	1.59	-12.39

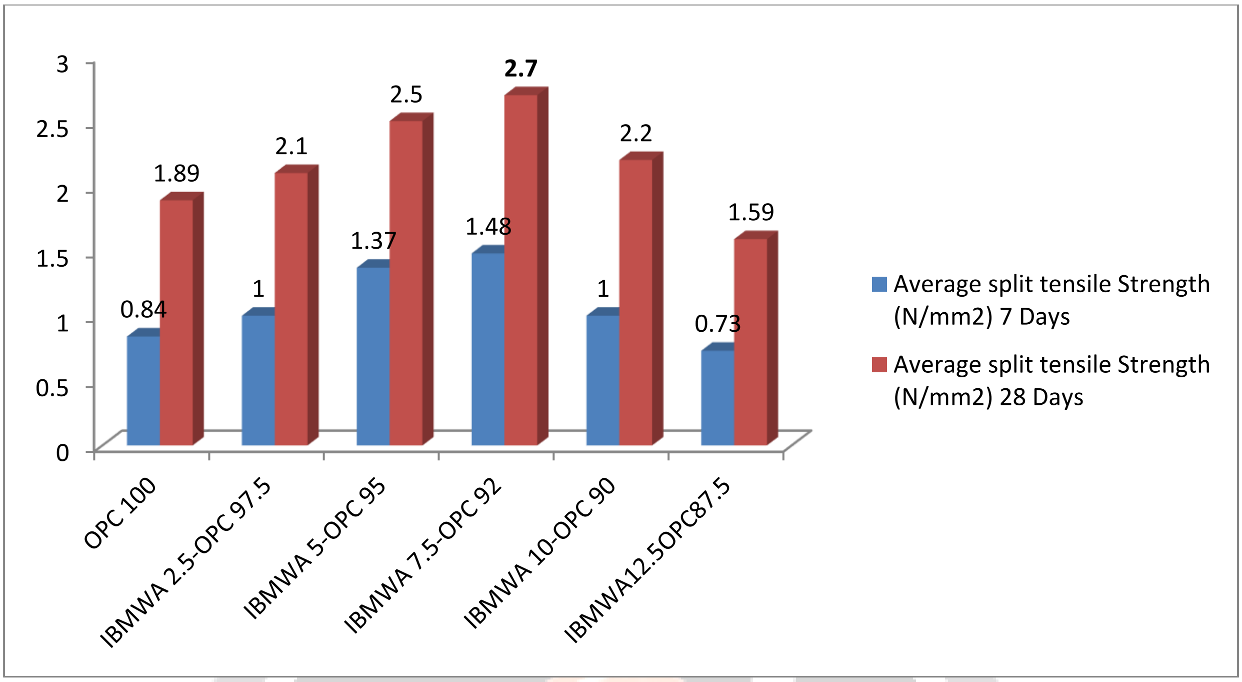


FIGURE 3: SPLITTING TENSILE STRENGTH

3.3 Sorptivity test

The various time intervals at which the readings have been taken are represented in seconds. The weight of the various samples are recorded at all the stipulated times and the change in weight of the sample with respect to its initial oven dried weight is calculated. This increase in weight observed represents the water absorption of the sample and the same is represented in terms of volume of water ingress through the surface, i. e. as flow (Q) in mm^3. The penetration depth (mm) for each of the sample at every single time interval is determined by dividing the flow with surface area exposed to absorption.

TABLE 4 :SORPTIVITY TEST CONTROL CONCRETE

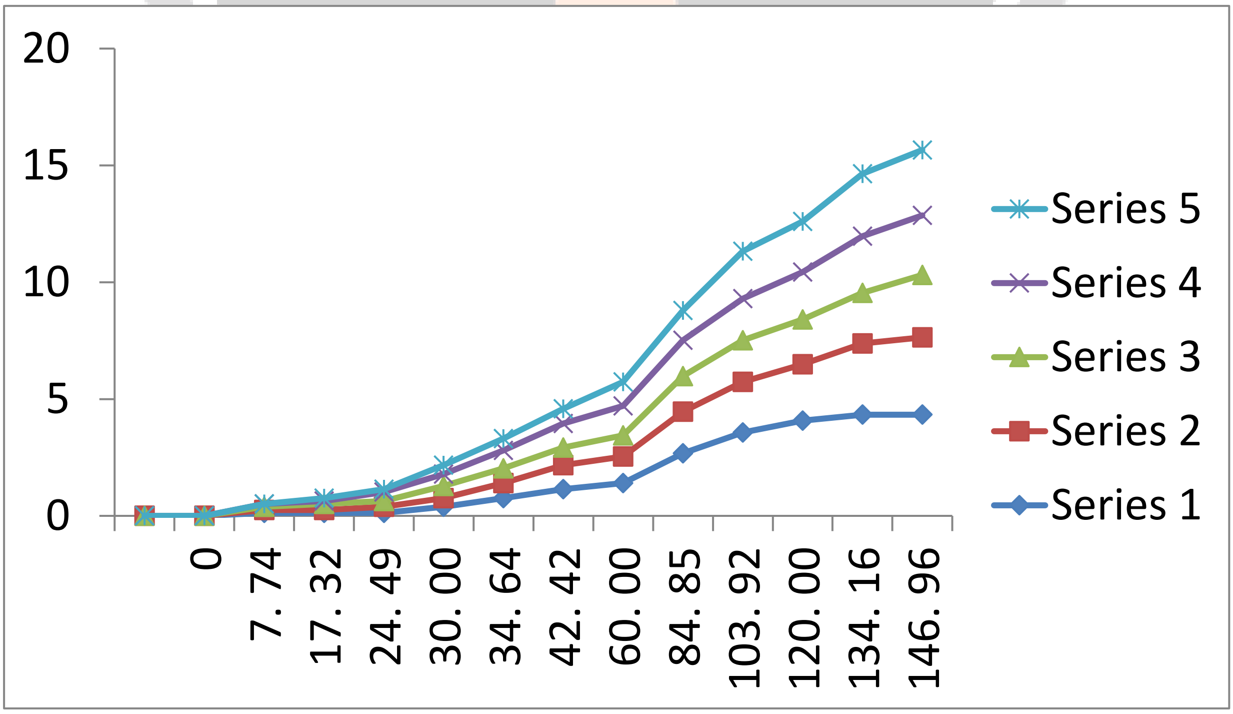
Time (S)	$\sqrt{T}$ ($\sqrt{S}$)	CONTROL SIFCON		
		Q (mm^3)	A (mm^2)	Q/A (mm)
0	0	0	7854	0
60	7. 74	1000	7854	0. 13
300	17. 32	4000	7854	0. 50
600	24. 49	6000	7854	0. 75
900	30. 00	7000	7854	0. 90
1200	34. 64	9000	7854	1. 11
1800	42. 42	16000	7854	2. 03
3600	60. 00	24000	7854	3. 06
7200	84. 85	31000	7854	3. 95
10800	103. 92	34000	7854	4. 33
14400	120. 00	38000	7854	4. 89
18000	134. 16	42000	7854	5. 44
21600	146. 96	46000	7854	5. 86

Figure shows graphs plotted between penetration depth and square root of time for each of the different specimens. The water gain of the specimen with respect to increasing time is observed to follow an increasing trend. The sorption coefficient is given by the slope of the trend line followed.

TABLE 5 SORPTIVITY VALUES FOR IBWA REPLACEMENT

√T (√S)	OPC 100	IBWA 2.5-OPC97.5	IBWA 5-OPC 95	IBWA 7.5-OPC92.5	IBWA 10-OPC 90
0	0.000	0.000	0.000	0.000	0.000
7. 74	0.127	0.127	0.127	0.127	0.000
17. 32	0.127	0.127	0.255	0.127	0.127
24. 49	0.127	0.255	0.255	0.382	0.127
30. 00	0.382	0.382	0.509	0.509	0.382
34. 64	0.764	0.637	0.637	0.764	0.509
42. 42	1.146	1.019	0.764	1.019	0.637
60. 00	1.401	1.146	0.891	1.273	1.019
84. 85	2.674	1.783	1.528	1.528	1.273
103. 92	3.565	2.165	1.783	1.783	2.037
120. 00	4.074	2.419	1.910	2.037	2.165
134. 16	4.329	3.056	2.165	2.419	2.674
146. 96	4.329	3.310	2.674	2.546	2.801

FIGURE 4 : PENETRATION DEPTH Vs TIME FOR IBWA REPLACEMEN



From the figure 4 it is observed that, for the replacement of silica fume, the sorption coefficient was within acceptable values and even lesser than that of control SIFCON. The maximum sorption coefficient of silica fume attained at 5% as 3. 4 x 10^{-2} mm/$s^{-1/2}$ which is even lesser than the control SIFCON and thus indicates a good durability nature of silica fume and may be attributed to the decrease in number of pores in the specimen due to the optimum amount of silica fume in it.

CONCLUSIONS

From the above experimental work the following conclusions were drawn:

7.5% of IBWA replacement of hollow block gives maximum compressive strength as compared to conventional hollow block

7.5% of IBWA replacement of cement in concrete gives maximum compressive strength as compared to conventional concrete

7.5 % of IBWA replacement of cement in concrete gives maximum splitting tensile strength as compared to conventional concrete

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