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Use of Hospital Waste as a Partial Replacement of Cement

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ABSTRACT

This investigational study carried out to examine the behavior and strength of concrete by replacing the cement content with Hospital waste ash at 2.5,5,10,15 and 20 %. Many tests are performed to analyze the compressive strength of concrete with different mixes at 7,14 and 28 days. The compressive strength is found to be satisfactory at 2.5% replacement of Hospital waste ash.

Keywords - Concrete, Hospital Waste Ash, hospital waste , replacement compressive strength

INTRODUCTION

World output of cement in 2009 was about 2.8 gigatons [1]. Cement production is responsible for 5% of global anthropogenic CO2 emissions and 7% of industrial fuels use [2,3]. Thus, the cement industry is an important industrial polluter in terms of greenhouse gases (GHG), and emission reductions in this sector will lead to significant decreases of overall GHG releases.By using of hospital waste ash may reduce the cost of a construction project and may appear the step towards the healthy and pollution free environment.On the other hand management of waste is a major problem in most of the countries, specially Hospital Waste. This waste has adverse effect on the Health hazards i.e Injuries and accident, Infectious medical waste risk ,Hazardous medical waste risk and Environmental Hazardsi.e Pollutants from medical waste, Accumulation of toxic chemicals within soil, Ground water contamination ,Windblown dusts Public nuisance, Reduce water percolation. In Pakistan the current status of hospital waste is alarming as ~0.8 million tonnes of waste is produced daily from hospitals (4).

The INCINERATION (burning) of Hospital Solid Waste (HSW) as a method of volume reduction is currently receiving wide spread attention especially in Pakistan. The Incineration of HSW significantly reduces the volume of waste but the resulting ash can create additional disposal problems.

For the purpose of technical evaluation the Hospital waste ash was collected from the locally available Incinerators installed at various hospitals.

REVIEW OF LITEREATURE

Al-Mutairi*et al.*, (2004) compared the compressive strength of mixtures made with bottom and fly hospital ash in order to evaluate the effectiveness of reusing hospital incinerator ash. Results showed that when 5% microsilica and fly ash were incorporated, the compressive strength of cubes was further increased.[5] (Genazzini*et al.*, 2003) the chance of incorporating hospital waste ashes in Portland cement-based materials is presented here. Ash characterization was performed by chemical analysis, X-ray diffraction, radioactive material detection. (Genazzini*et al.*, 2005)

The new cement–ash composite systems have been tested for future applications in building materials. The additions of hospital ash in cement matrices to be potentially used as construction elements. This involved the assessment of the effect of the additions on the physico mechanical properties of the building materials.

Filipponi*et al.*, (2003) prepared the different mixes by blending hospital waste incinerator bottom ash with ordinary Portland cement in different proportions and at different water dosages. Results at curing times longer than 28 days and for waste dosages higher than 50% suggested that bottom ash exhibited weak pozzolanic property. Al-Rawas et al., (2005) investigated the use of incinerator ash as a replacement for sand and cement in cement mortars. The cement, sand and water mixing proportions were 1:3:0.7 respectively. Results showed that incinerator ash caused a reduction in slump values when it was used as a replacement for sand while an opposite trend was observed when it was used as a replacement for cement[6].Aubert et al., (2004) evaluated the use of biomedical waste ash on the compressive strength and the durability of hardened concrete and suggest the use of waste in concrete constitutes a potential means of adding value. Anastasiadou et al., (2011) evaluated the mechanical properties of the medical waste incineration bottom ash using different amounts of ordinary Portland cement (OPC) as a binder. Result showed that strength decreased as the percentage of cement loading was reduced. (Azni*et al.*, 2005) In Germany 50% of the ash produced from incinerated waste is used for the manufacturing of sound insulation walls at National roads, as well as, sub layers on the streets. 60% of the bottom ash is used for the construction of asphalt and as a sub layer of roads in Netherlands[7]. Anastasiadou*et al.*, (2011) studied the cement based stabilization/solidification of fly and bottom ash Anastasiadou et al., (2011) studied the cement based stabilization/solidification of fly and bottom ash generated from

S.No	SIEVE #	WEIGHT RETAINED (gram)	CUMMULATIVE WEIGHT RETAINED (gram)	% WEIGHT RETAINED	CUMULATIVE % RETAINED	CUMULATIVE PERCENTAGE PASSING	ASTM Range (C 33)
1.	4	0	0	0	0	100	95 to 100
2.	8	20	20	4	4	96	80 to 100
3.	25	330	350	66	70	30	-
4.	50	125	475	25	95	5	5 to 30
5.	80	20	495	4	99	1	-
6.	100	5	500	1	100	0	0 to 10
7.	Pan	0	500	0	100	0	-

incinerated hospital waste to reduce the leachability of the heavy metals present in these materials.

METHODOLOGY

Collection of Material & Testing

1. Cement

Ordinary Portland Cement (OPC) from Cherat Cement factory was used. ASTM Designation: C150-04 Type I [8].

a. Fineness of Cement

- Weight Retained= 5gram
- Total Weight of Cement Sample= 100 gram
- Fineness= Total Weight-Weight Retained/Weight Retained
- =100-5/100*100=95%

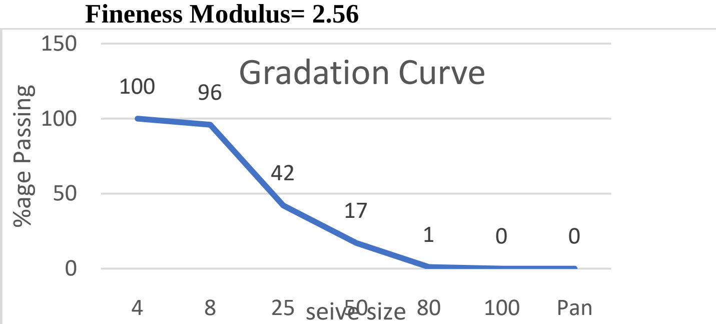
2. Fine Aggregate

Dry Lawrancepur Sand was used. The Sieve analysis was carried out according to **ASTM C136-01**[9].

a. Seive Analysis

Total weight of Aggregates = 500 grams

Fineness Modulus= 2.56



b. Moisture Content

$$Moisture\ Content = \frac{Weight\ of\ water}{Oven\ Dry\ Weight} * 100$$

- Weight of Water= 1.25gram

S.No	SIEVE SIZE	WEIGHT RETAINED (gram)	CUMMULATIVE WEIGHT RETAINED(gram)	% WEIGHT RETAINED	CUMULATIVE % RETAINED	PERCENTAGE PASSING
1.	1.5	0	0	0	0	100
2.	1	444	444	14.8	14.8	85.2
3.	¾	985	1429	32.83	47.63	52.37
4.	½”	1190	2619	39.67	87.3	12.7
5.	3/8	260	2879	8.67	95.97	4.03
6.	3/16	90	2969	3	98.97	1.03
7.	Pan	31	3000	1.03	100	0

- Oven Dry Weight of F.A= 48.75gram
- Moisture Content of F.A= 2.5%

c. Absorption

$$Water\ Absorption = \frac{SSD\ Weight - Oven\ Dry\ Weight}{Oven\ Dry\ Weight} * 100$$

- SSD Weight = 51.25gram
- Oven Dry Weight of F.A= 48.75gram
- Absorption of F.A= 3.64%

d. Specific Gravity

$$Sp.gr = \frac{W2 - W1}{(W4 - W1) - (W3 - W2)}$$

- Weight of Empty Container=W1= 8.5kg
- Weight of Container + F.A=W2= 12.43kg
- Weight of water + F.A + Container =W3= 15.990kg
- Weight of Container + Water =W4= 13.82kg
- Sp.gr of F.A=2.23

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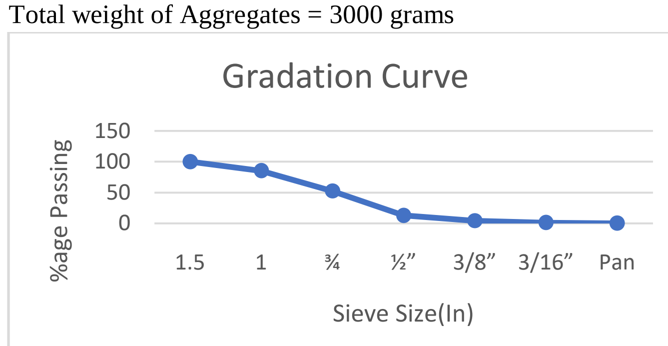
3. COARSE AGGREGATE

Crushed Stone from Margala was used. The Sieve analysis was carried out according to ASTM C136-01.[10]

a. Seive Analysis

Total weight of Aggregates = 3000 grams



b. Moisture Content

$$Moisture\ Content = \frac{Weight\ of\ water}{Oven\ Dry\ Weight} * 100$$

- Weight of Water= 0.125gram
- Oven Dry Weight of C.A= 48.87gram
- Moisture Content of C.A= 0.25%

c. Absorption

- Weight of Water= 50.325gram
- Oven Dry Weight of C.A= 48.87gram
- Absorption of C.A= 1.92%

e. Specific Gravity

f. $$Sp.gr = \frac{W2 - W1}{(W4 - W1) - (W3 - W2)}$$

- Coarse Aggregate
- Weight of Empty Container=W1= 8.5kg
- Weight of Container + C.A=W2= 12.760kg
- Weight of water + C.A + Container =W3= 16.300kg
- Weight of Container + Water =W4= 13.82kg
- Sp.gr of C.A=2.39

4. Hospital Waste Ash (HWA)

The Hospital Waste ash collected from the Incinerators installed at **Hayatabad Medical Complex, Lady Reading Hospital,Khyber Teaching Hospital Peshawar.**
HWA includes broken glass bottles, metallic pieces including syringes and other surgical item.

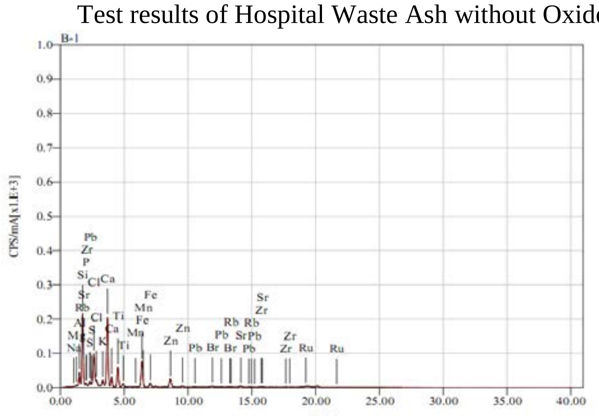
The following tests performed at laboratory for investigating the chemical properties of hospital ash in context of cement mechanism.

a. Los Angles Abrasion Test

In this test the Grinding of HWA carried out in
Los Angles Abrasion Machine with 11 Balls each of weight measured 450±5gm per ball and 4000 revolution in each batch of 5kg carried out.

b. X-Ray Fluorescence (XRF)

Test results of Hospital Waste Ash without Oxide



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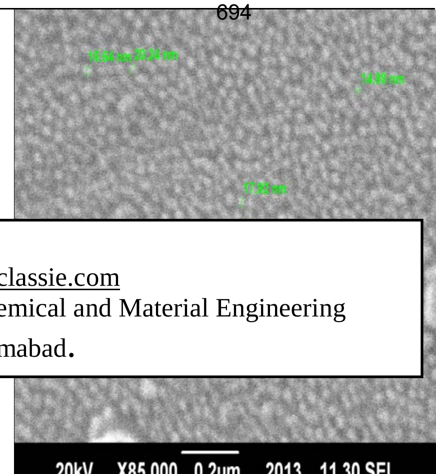

SOURCE
Range &OPC :www.classie.com
HWA : School of Chemical and Material Engineering (SCME), NUST, Islamabad.

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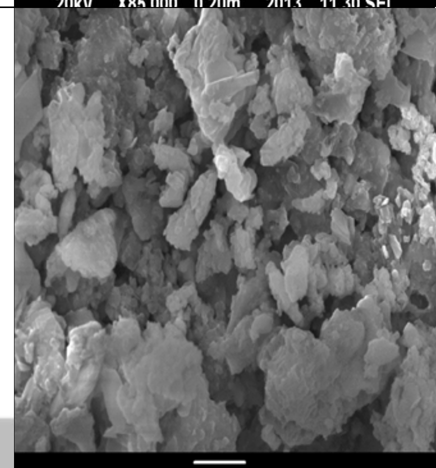

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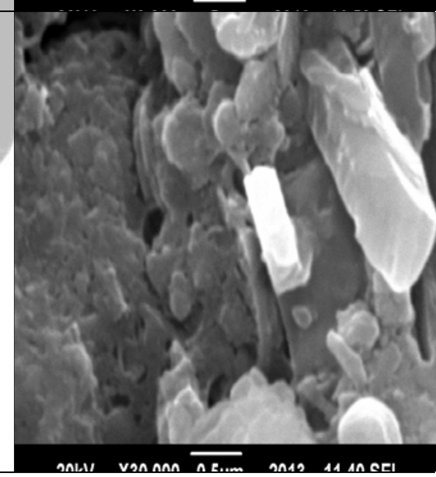
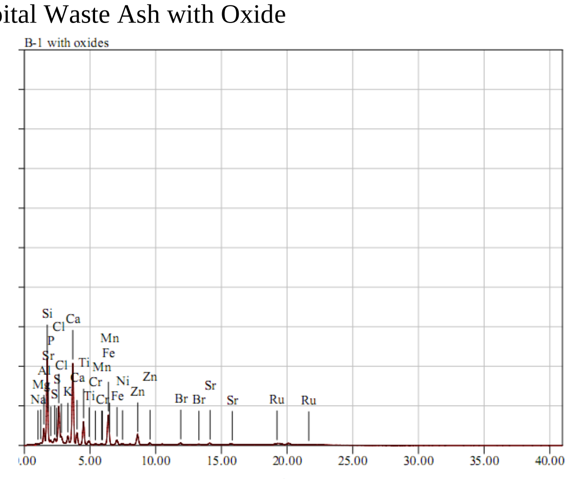


Hospital Waste Ash with Oxide



PROPERTY	RANGE	OPC

Silicon Dioxide SiO_2	18.907 – 29.29	25.74
Aluminum Oxide Al_2O_3	3.40-10.70	8.70
Ferric Oxide Fe_2O_3	0.150-4.18	2.03
Calcium Oxide CaO	49.28-68.94	55.15
Magnesium Oxide MgO	0.78-5.12	3.98
Sulfur Trioxide SO_3	1.91-4.689	3.18
Sodium Oxide Na_2O	0.021-1.1086	0.26

Water Content= 342.5lb/yd^3	Water Cement Ratio= 0.68

Table : Approximate Mixing Water and Air Content Requirements for Different Slumps and Maximum Aggregate Sizes (adapted from ACI, 2000)

Slump	Mixing Water Quantity in kg/m^3 (lb/yd^3) for the listed Nominal Maximum Aggrega						
	9.5 mm (0.375 in.)	12.5 mm (0.5 in.)	19 mm (0.75 in.)	25 mm (1 in.)	37.5 mm (1.5 in.)	50 mm (2 in.)	75 mm (3 in.)
Non Air Entrained PCC							
25 - 50 (1 - 2)	207 (350)	199 (335)	190 (315)	179 (300)	166 (275)	154 (260)	130 (220)
75 - 100 (3 - 4)	228 (385)	216 (365)	205 (340)	193 (325)	181 (300)	169 (285)	145 (245)
150 - 175 (6 - 7)	243 (410)	228 (385)	216 (360)	202 (340)	190 (315)	178 (300)	160 (270)
Typical entrapped air (percent)	3	2.5	2	1.5	1	0.5	0.3
Air-Entrained PCC							
25 - 50 (1 - 2)	181 (305)	175 (295)	168 (280)	160 (270)	150 (250)	142 (240)	122 (205)
75 - 100 (3 - 4)	202 (340)	193 (325)	184 (305)	175 (295)	165 (275)	157 (265)	133 (225)
150 - 175 (6 - 7)	216 (365)	205 (345)	197 (325)	184 (310)	174 (290)	166 (280)	154 (260)
Recommended Air Content (percent)							
Mild Exposure	4.5	4.0	3.5	3.0	2.5	2.0	1.5
Moderate Exposure	6.0	5.5	5.0	4.5	4.5	4.0	3.5

Table : Water-Cement Ratio and Compressive Strength Relati (after ACI, 2000)

28-Day Compressive Strength in MPa (psi)	Water-cement ratio by weight	
	Non-Air-Entrained	Air-Entrained
41.4 (6000)	0.41	-
34.5 (5000)	0.48	0.40
27.6 (4000)	0.57	0.48
20.7 (3000)	0.68	0.59
13.8 (2000)	0.82	0.74

SOURCE

Range &OPC :www.classie.com

HWA : School of Chemical and Material Engineering (SCME), NUST, Islamabad

c. Scanning Electron Microscopy (SEM)

This test conducted to obtain particle size and shape of HWA. The size of particles found less than 12micron and the shape observed highlyirregular.

5. **Water**: Potable water was Used

Specimen Designation

- The mix were abbreviated in two ways

- CM and HWAH
- CM is Control Mix
- HWAH represented replaced amount of Cement.
- CM, 2.5H, 5H, 10H,15H and 20H

Mix Design

Definition

"Mix design is the science of determining the relative proportional of the ingredients of concrete to achieve the desired properties in the most economical way"

Types of Mix Design

1. Nominal Mix
2. Design Mix
3. Trial Mix

Factors Defining the choice of Mix Proportions

1. Compressive Strength
2. Workability
3. Durability
4. Type, size and grading of aggregates
5. Aggregate-cement ratio

ACI Method of Mix Design

- ✓ Compressive Strength= 3000psi
- ✓ Slump= 2to3in

Values from Tests

- Specific Gravity of Fine Aggregate=2.23
- Specific Gravity of Coarse Aggregate=2.39
- Moisture Content of Fine Aggregate=2.5%
- Moisture Content of Coarse Aggregate=0.25%
- Absorption of Fine Aggregate=3.64%
- Absorption of Coarse Aggregate=1.92%
- Fineness Modulus of Fine Aggregate=2.56
- Maximum Size of Aggregate= 1/2in
  Air Content= 2%

Amount of Cement=Water content/ Water Cement Ratio= 342.5/0.68= **503.67 lb/yd^3**

Table : Volume of Coarse Aggregate per Unit Volume of PCC for Different Fine aggregate Fineness Moduli *for Pavement PCC* (after ACI, 2000)

Nominal Maximum Aggregate Size	Fine Aggregate Fineness Modulus			
	2.40	2.60	2.80	3.00
9.5 mm (0.375 inches)	0.50	0.48	0.46	0.44
12.5 mm (0.5 inches)	0.59	0.57	0.55	0.53
19 mm (0.75 inches)	0.66	0.64	0.62	0.60
25 mm (1 inches)	0.71	0.69	0.67	0.65
37.5 mm (1.5 inches)	0.75	0.73	0.71	0.69
50 mm (2 inches)	0.78	0.76	0.74	0.72

Notes:

- Amount of Fine Aggregate= 3890-1552.5-503.67-342.5=1491.33 lb/yd^3

Maximum Size of Aggregate (in.)	First Estimate of Concrete Weight (lb/yd^3)	
	Nonair-entrained Concrete	Air-entrained Concrete
3/8	3840	3690
1/2	3890	3760
3/4	3960	3840
1	4010	3900
1½	4070	3960
2	4120	4000
3	4160	4040
6	4230	4120

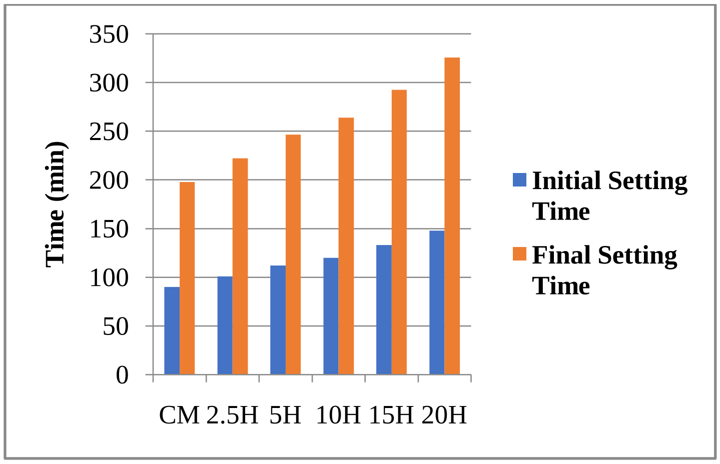
- Moisture of C.A= (3.64-2.5)*1593/100= 18.16 lb/yd^3
- Moisture of F.A= (1.92-0.25)*1450.83/100=24.22 lb/yd^3
- Total Water= 342.5+18.16+24.22=384.88 lb/yd^3

Mix	Cement lb/yd^3	HWA lb/yd^3	W/C + HWA	Water lb/yd^3	F.A lb/yd^3	C.A lb/yd^3
CM	503.67	-	0.68	384.88	1491.33	1552.5
2.5H	491.09	12.59	0.68	384.88	1491.33	1552.5
5H	478.49	25.18	0.68	384.88	1491.33	1552.5
10H	453.30	50.367	0.68	384.88	1491.33	1552.5
15H	428.12	75.55	0.65	384.88	1491.33	1552.5
20H	402.94	100.73	0.65	384.88	1491.33	1552.5

Now the above mix design data the required tests performed in the laboratory as per ASTM requirements whose results are given as under

Initial and Final Setting Time of Concrete Mixes

Mixing: ASTM C191-04 [11]



Consistencies of Mixes

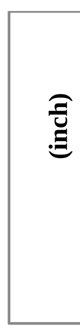
ASTM C187-98C'[12]

Mix	Consistency(% of Water)
CM	30
2.5H	30.5
5H	31
10H	32
15H	33
20H	34

Slump of Mix

ASTM

Mix	Slump Value (in)
CM	1.80
2.5H	1.77
5H	1.69
10H	1.65
15H	1.60
20H	1.56



Compressive Strength of Mixes @7DaysASTM C39/C 39M-03'[14]

Cylinder	Test Date	Dimension (in)		Area (in^2)	Load (lbs)	Compressive Strength (psi)
		Length	Dia			
CM	-	12	6	28.27	45000	1559.25
2.5H	-	12	6	28.27	45000	1559.25
5H	-	12	6	28.27	43000	1521.04
10H	-	12.05	6	28.27	36000	1273.43
15H	-	12.10	6	28.27	29000	1025.82
20H	-	12.15	6	28.27	20000	707.46

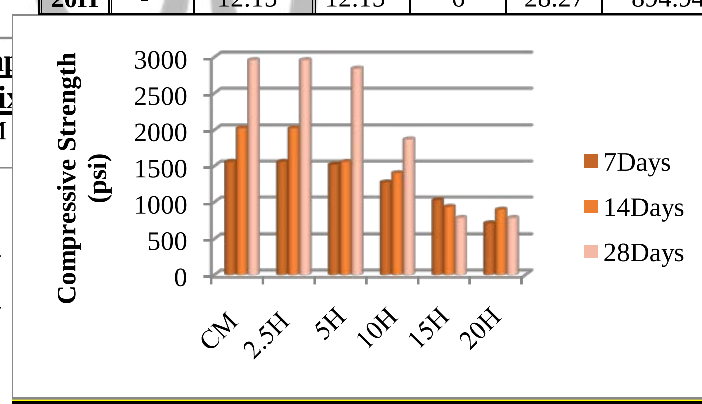
Mix	Initial Setting Time(min)	Final Setting Time(min)
CM	90	198
2.5H	101	222.2
5H	112	246.4
10H	120	264
15H	133	292.6
20H	148	325.6

Compressive Strength of Mixes @14Days[14]

Cylinder	Test Date	Dimension (in)		Area (in^2)	Load (lbs)	Compressive Strength (psi)
		Length	Dia			
CM	-	12	6	28.27	45000	2957.19
2.5H	-	12	6	28.27	45000	2957.19
5H	-	12	6	28.27	43000	2840.46
10H	-	12.05	6	28.27	36000	1867.70
15H	-	12.10	6	28.27	29000	778.21
20H	-	12.15	6	28.27	20000	778.21

Compressive Strength of Mixes @28Days [14]

Cylinder	Test Date	Dimension (in)		Area (in^2)	Load (lbs)	Compressive Strength (psi)
		Length	Dia			
CM	-	12	12	6	28.27	2023.34
2.5H	-	12	12	6	28.27	2023.34
5H	-	12	12	6	28.27	1556.42
10H	-	12.05	12.05	6	28.27	1400.77
15H	-	12.10	12.10	6	28.27	933.85
20H	-	12.15	12.15	6	28.27	894.94



I. RESULTS AND DISCUSSIONS

This study carried out to evaluate the feasibility of using of hospital waste ash as partial replacement of cement. The main variable in this research is the amount of hospital waste ash (2.5,5,10,15, and 20% by weight of cement) while the amount of cementations material, water cement ratio, fine and coarse aggregate content were kept constant.

Test results substitute that hospital waste ash can be used in concrete. XRD (X-Ray Diffraction) of hospital waste ash showed that it is rich in calcite while scanning electron micrographs indicated that the particles of hospital waste ash have highly irregular shape. The slump value, density of fresh concrete and water absorption decreased with the increase in the quantity of hospital waste ash in the mix. At 7,14and 28 days of testing, the compressive strength of mixes with 2.5H hospital waste ash was equal to the Control mix and results of the CM (Control Mix) showed higher strength than the hospital waste ashmixes except the mix containing 2.5% hospital waste ash by weight of cement.

CONCLUSIONS

- Based on the experimental results, following conclusions Can be drawn.
- Low cost concrete i.e 2.5% of cost saving can be achieve by utilizing HWAAs partial replacement of cement in concreteWithout compromising the strength parameters.
- The setting time increased while the density andWater absorption of mixes decreased with theIncrease in the percentage of HWA in the mix.
- The utilization of HWA as partial replacement ofCement in concrete solves the problem of it's theDisposal thus keeping the environment free fromPollution.
- In future research, further scientific investigation should be carried out to endorse the results

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