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Research paper

Performance of wood ash blended reinforced concrete beams under acid (HCl), base (NaOH) and salt (NaCl) curing conditions

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Abstract

Nowadays disposal of wood ash generated from various sources became a very challenging problem. Utilization of wood ash in cement and concrete was started from last 10 years. In this research, an attempt was done to examine the durability properties of reinforced cement concrete with 5, 10, 15 and 20 percentage replacement of cement with wood ash in concrete. The specimens with all proportions were cast, cured 28 days for one set specimens while another 3 set were cured in acid (HCl), base (NaOH) & salt (NaCl) conditions for 90 days. All specimens were tested to failure under loading frame of 500 kN capacity with 1 kN/sec as the rate of loading, weight loss, ultimate load, and deflection were determined. The better performance is shown by blended specimens against NaCl, NaOH and week resistance against HCl. The concrete with 5 percent replaced with wood ash can be used coastal regions as a result of greater resistance to against NaCl.

Keywords: *Wood Ash; Durability; Flexure Strength; Weight Reduction and Deflection.*

1. Introduction

Wood ash is the residue generated from wood-fired power plants, paper mills and other wood-burning facilities by combustion of wood and wood products [1-3]. The disposal costs of the ash are rising and volume of ash is increasing, a sustainable ash management which integrates the ash within the natural cycles needs to be employed [4-6].The utilization of pozzolanic materials like fly ash, GGBS, metakaolin and rice husk ash in cement and concrete manufacturing was implemented for several decades [7-11].
Wood ash is pozzolanic material, it can blend in concrete partially by cement[12-13]. Recent studies on the use of wood ash as a new brick material supplement appear to be a viable solution not only to the environmental problem but also to the problem of to economic design of buildings [14-17]. Wood ash blended plain cement concrete shown higher performance at 5 percentage and poor results beyond 20 percentage partial replacement [18-21].There is no experimental data was available on the durability of wood ash blended reinforced cement concrete. In this study, an attempt was made that wood waste ash concrete has several unique characteristics which make it competitive among other building materials. The objective of this paper is to evaluate the durability of wood ash blended reinforced cement concrete under acid (HCl), base (NaOH) and salt (NaCl) conditions.

2. Materials

OPC 43 grade cement was used in this research conforms to IS 12260:1987. Table 1shows the chemical analysis of wood ash sample collected from boiler shown in Figure 1 located in K L University, A.P., India. The wood ash passed through 90-micron sieve used in this research, shown in Figure 2. Table 2 shows the properties of VIZAG TMT 500 steel bars of comprising 10Ø for stirrups and 12Ø main reinforcement were used in experimental work. In this research, the water of 7.5 pH value was used for ordinary curing.



Fig. 1: Wood Ash Burning Boilers.

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Fig. 2: Wood Ash.

Table 1: Chemical Analysis of Wood Ash

S. No.	Component	% of mass
1	Silicaas SiO_2 (%)	18.7
2	Alumina as Al_2O_3 (%)	4.62
3	Iron as Fe_2O_3 (%)	2.68
4	Calcium as Cao (%)	40.06
5	Magnesium as MgO (%)	7.12
6	Potassium as K_2O (%)	2.02
7	Sodium oxide, Na_2O (%)	3.62
8	Moisture (%)	0.24
9	Loss on ignition (LOI) %	19.76

3. Experimental investigation

The experimental investigation was carried out by substitution of wood ash of 2.48 specific gravity by weight varying from 0, 5, 10, 15 and 20 percentages. C, A, B, S series specimens represent cured with water, acid, base and salt respectively. M25 grade of concrete with 1: 1.74: 2.83 proportion and 0.5 water/cement ratio. Table 3 shows compressive strength (average of 3 specimens) of wood ash blended cubes after 28 days of curing with water. Figure 3 shows the details of reinforced concrete specimens. A total number of 60 R.C.C specimens were cast, cured in water for 28 days. 163 ml of HCl, 75 grams of NaOH and 4.5 Kg s of NaCl mixed with 183 liters of water respectively.

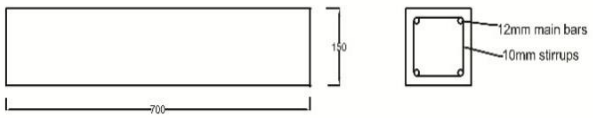


Fig. 3: Details of R.C.C. Specimen.

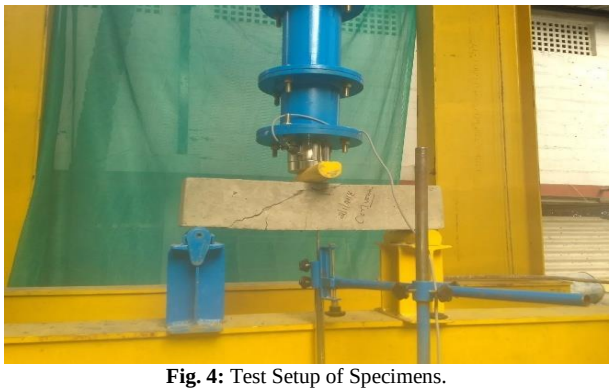


Fig. 4: Test Setup of Specimens.

Table 2: Compressive Strength of Wood Ash Blended Cubes

S. No.	% of replace-ment	Compressive strength after 28 days of curing (Mpa)
1	0	32.6
2	5	31.2
3	10	29.3
4	15	27.62
5	20	25.34

A set of 15 specimens were tested after 28 days of curing whereas another 3 sets of specimens cured in plastic vessels as shown in Figure 4 with acid, base, and salt respectively for 90 days. Figure 4. Shows the test setup of the specimen, testing of specimens carried out by the loading frame of 50kN capacity by keeping the rate of loading of 1 kN/sec. 3 sets of specimens were tested to failure after 90 days of curing, ultimate loads are shown in Table 4. Table 5 shows the weights of the 2nd, 3rd and 4thset of specimens before curing as well as after curing by removal of moisture.

Table 3: Properties of Steel Reinforcement

Si. No	Ø of Speci-men	Area of the specimen (mm^2)	Weight of the specimen (Kg)	Ultimate tensile strength (MPa)	% of elonga-tion (mm)
1	10	78.73	0.618	635.51	22
2	10	78.47	0.618	625.07	20
3	10	78.47	0.616	625.09	24
4	12	113.1	0.888	589.79	21.67
5	12	113.3	0.889	597.70	23.33
6	12	113.1	0.888	595.38	23.33

Table 4: Ultimate Load and Deflection at Ultimate Load of R.C.C. Specimens

S. No	Speci-men	Ultimate load (k N)	Flexural Strength (MPa)	Deflection at ultimate load (mm)
1	C0WA	106.4	22.07	7.58
2	C5WA	97.6	20.24	7.14
3	C10WA	94.6	19.62	7.20
4	C15WA	85.8	17.80	6.39
5	C20WA	78.3	16.24	5.86
6	A0WA	109.7	22.75	9.86
7	A5WA	107.4	22.28	8.05
8	A10WA	99.6	20.66	6.6
9	A15WA	86.5	17.94	5.43
10	A20WA	82.8	17.17	8.45
11	B0WA	104.7	21.72	10.86
12	B5WA	109	22.61	8.26
13	B10WA	100.3	20.80	6.84
14	B15WA	77.1	15.99	6.48
15	B20WA	76.2	15.80	8.81
16	S0WA	93.6	19.41	6.22
17	S5WA	112.7	23.37	8.45
18	S10WA	106.7	22.13	7.42
19	S15WA	98.9	20.51	7.12
20	S20WA	89.6	18.58	7.03

Table 5: Weights of Specimens before Curing and After Curing

S. No	% of re-placement	Acid Series (Kg s)		Base Series (Kg s)		Salt Series(Kg s)	
		Before Curing	After curing	Before Curing	After curing	Before Curing	After curing
1	0	42.58	41.9	42.72	41.95	42.56	42.35
2	5	42.98	41.72	42.46	42.14	42.79	42.66
3	10	42.62	42.49	42.88	42.42	42.44	42.35
4	15	43.5	42.6	42.54	42.38	42.78	42.67
5	20	42.44	42.29	41.89	41.76	42.87	42.8

4. Results and discussions

The weight difference was very slight for all mixes other than control specimens, little deterioration was observed. The ultimate load of control specimen after 28 days of curing shown 106.4 kN which was higher among the first set of specimens. C5WA and C20WA shown 8.27% and 26.12% lower than control mix respectively. Lower flexural strength was observed due to poor results of the compressive strength of wood ash blended concrete at 28 days of curing [2].Figure 5 shows the load-deflection curves of the first set of specimens, deflection of first set specimens was proportional to ultimate load.

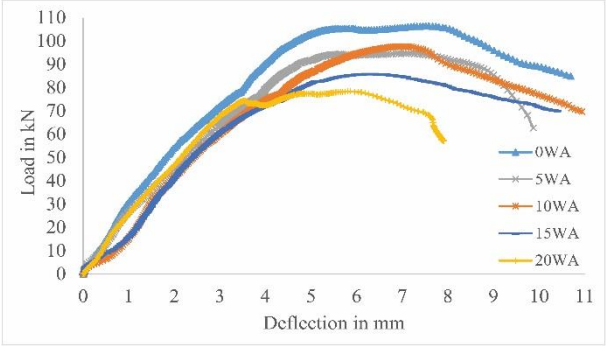


Fig. 5: Load-Deflection Curves for the First Set of Specimens.

The ultimate load of control specimen for the second set was 109.7 kN which was higher among the second set of specimens. A5WA and A20WAshown 2.09% and 24.52% lower than control specimen respectively. Figure 6 shows the load-deflection curves of the second set of specimens. The highest ultimate load of 109.0 kN was observed for B5WA in third of specimens, 4.31% higher than control specimen and B20WA shown 27.22% lower than control specimen. Figure 7 shows the load-deflection curves of the third set of specimens.

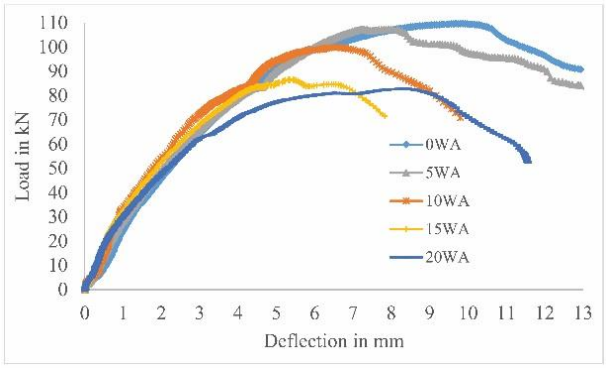


Fig. 6: Load-Deflection Curves for the Second Set of Specimens

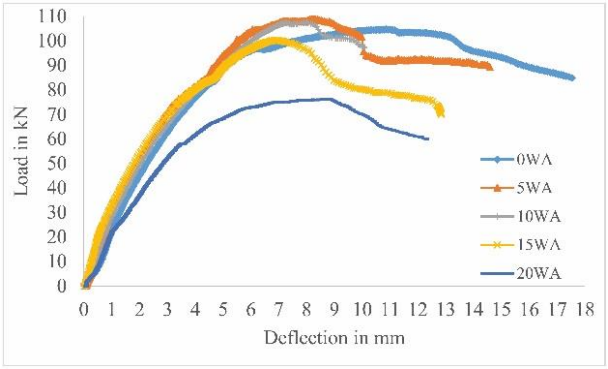


Fig. 7: Load-Deflection Curves for the Third Set of Specimens.

The highest ultimate load of 112.7 kN was observed for B5WA in the fourth set of specimens. B5 WA, B10WA and B15WA shown 16.94%, 11.62%, and 4.7% higher and B20WA 27.22% lower than control specimen. Figure 8 shows the load-deflection curves of the third set of specimens. The wood ash was very finer material than cement, it may fill the voids between the cement in hardened concrete very difficult to penetrate NaCl through the surface of the concrete.

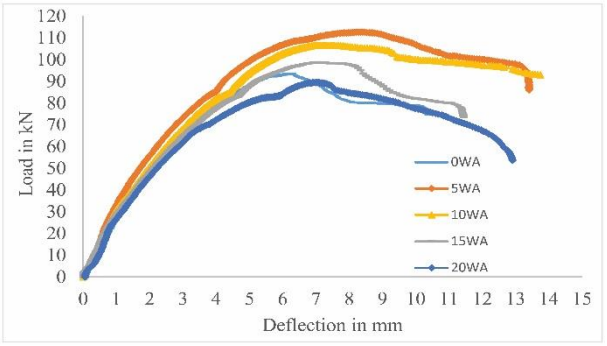


Fig. 8: Load-Deflection Curves for the Fourth Set of Specimens

5. Conclusions

The durability of the R.C.C was improved by the partial blending of wood ash in some aspects. Wood ash blended mixes shown poor results against HCl attack and greater resistance against NaCl and NaOH attack.Spalling of material from control specimen was higher than all blended mixes. The greater performance is shownat 5% replacement of cement with wood ash. B5WA S5WA shown 16.94% higher, B5WA shown 4.31% higher, A5WA shown 2.09% lower than control mix. S5WA.5% utilization ofwood ash in R.C.C is recommended to get optimum results. The construction of R.C.C buildings in coastal areas with this type of concrete is suggestible to avoid failures from high salty climatic conditions.

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