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MECHANICAL PROPERTIES AND DURABILITY OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH WOOD WASTE ASH

Mrs.B. Sahithi Chandra, Mrs. Gogikar Chandhan Devi

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.

Introduction

Concrete is the largest volume material used by man and is irreplaceable for large infrastructure developments. The success of concrete comes from, on the one hand the broad availability and low cost of its components, and on the other hand, the ease with which it can be prepared. Every year more than 1 m3 of concrete is produced per person worldwide with Portland cement being the key ingredient, but producing the greatest environmental burden. Presently around 3 billion tons of Portland cement are consumed worldwide and for the production of every 600 kg of cement, approximately 400 kg of carbon dioxide gas is released, around 5–8% of all man made CO2. While cement production in its beginnings only focused on ordinary Portland cement, later cements with several main constituents were produced by replacing parts of the clinker content by supplementary cementitious materials.

1,2 Assistant Professor,

1,2, Department of Civil Engineering,,
1,2 Global Institute of Engineering and Technology, Moinabad, Hyderabad

Ecological or environmental benefits of alternative supplementary materials include the diversion of non-recycled waste from landfills for useful applications, the reduction in the negative effects of producing cement powder, namely the consumption of non-renewable natural resources, the reduction in the use of energy for cement production and the corresponding emission of greenhouse gasses. Biomass may be used for energy production at different scales, including large-scale power generation, or small-scale thermal heating projects at governmental, educational or other institutions. Biomass comes from both human and natural activities and incorporates by-products from the timber industry, agricultural crops, forestry residues, household wastes and wood. Though timber processing waste is a sustainable and renewable source of fuel for energy production, the thermal process leads to significant amounts of fine wood waste ash as a by-product material which, if not managed properly, may result in serious environmental and health problems.

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. 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.The utilization of pozzolanic materials like fly ash, GGBS, metakaolin and rice husk ash in cement and concrete man-ufacturing was implemented for several decades. Wood ash is pozzolanic material, it can blend in concrete partially by cement. 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. Wood ash blended plain cement concrete shown higher performance at 5 percentage and poor results beyond 20 percentage partial replacement.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.

Materials

OPC 53 grade cement was used in this research conforms to. The chemical analysis of wood ash sample collected from boiler of Birla A1 cement India. The wood ash passed through 90 micron sieve used in this research, shown in Figure 1. In this research, the water of 7.5 pH value was used for ordinary curing.

Fig. 1: Wood Ash.

Physical properties of wood ash-

Naik studied the physical and chemical characteristics of wood ash sourced from different mills. Wood ash was observed to be a heterogeneous mixture of different sized particles generally angular in shape. These particles basically consisted of partially burned or unburned wood and bark. To evaluate fineness, average amount of wood fly ash passing sieve #200(75 lm) is 50% and percentage of ash retained on sieve #325 (45 lm) is 31%. Test results showed the average unit weight of (ASTM C 29) of fly ash and bottom ash as 490 kg/m3 and 827 kg/m3 respectively and average specific gravity was 2.48 and 1.65 respectively. The average water requirement for fly ash was 116% and average auto clave expansion test value 0.2%. Udoeyo et alevaluated the physical properties of waste (WWA) wood ash used as partial replacement of cement. He reported that WWA had a specific gravity of 2.43, 1.81% of moisture content and a pH of 10.48. The average loss on ignition was 10.46. Rajamma et al reported the specific gravity of wood flyash to be 2.54 collected from a forestry biomass fired power plant and observed finer particles with average diameter of 50 lm. Wood ash was mainly found to be composed of highly angular particles with extensive surface porosity seen through SEM images. Naik et al studied wood ash from five various sources and they were designated as W1–W5. Specific gravity of different sources wood ash varied between 2.26 and 2.60 and fineness of the wood ash (% retained on 45 lm sieves) was between 23% and 90%. Physical properties of all the wood ashes.

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

Table 1: Chemical Analysis of Wood Ash

Experimental Investigation

For the study, six different proportion of concrete mixes (WA replacement of 5%, 10%, 15%, 18% and 20% by weight of cement) including the control mixture were prepared with water to binder ratio of 0.40 and 0.45 for design compressive strength of 20 N/mm2. For the compression test, blocks were casted in cube of dimension 10 · 10 · 10 cm for each water–binder ratio and for each replacement percentage. For split tensile strength test, cylinders were casted with diameter being 5 cm and height being 20 cm for each water–binder ratio and for each replacement percentage.

Test on Fine aggregate

- Specific gravity : 2.64
- Zone – II
- Fineness modulus : 2.99

Test on Coarse aggregate

- Specific gravity : 2.78
- Fineness modulus : 4.23

For flexural strength, beams were casted with dimension 10 · 10 · 50 cm for each waterbinder ratio and for each replacement percentage. Compacting of concrete was done by vibration as per IS: 516-1959.

Test on cement

Type of cement: Birla A1

Properties	Results
Specific gravity	3.14
Fineness	5%

Test on wood waste ash

Properties	Results
Specific gravity	3.14
Fineness	5%

Materials for m25 grade	0% Kg/m³	5% Kg/m³	10% Kg/m³	15% Kg/m³	20% Kg/m³	25 Kg
1. W/C ratio	0.5	0.5	0.5	0.5	0.5	0.5
2. Cement	394.32	374.61	354.89	335.81	315.76	29
3. Wood waste ash	0	19.71	39.43	59.54	78.86	98.
4. Coarse aggregate	1168	1168	1168	1168	1168	116
5. Fine aggregate	680	680	680	680	680	680
6. Water	197.16	197.16	197.16	197.16	197.16	197
Results for 7 days	24.44	27.25	30.37	20.74	20.44	19.
Results for 28 days	31.85	32.44	41.03	32.59	21.03	19.

After casting all the test specimens were stored at room temperature and then de-molded after 24 h, and placed into a water curing tank with a temperature of 24–34 _C until the time of testing. For each replacement percentage two specimens were casted for 7 days and two specimens were casted for 28 days test. The average result is reported in the paper. Test carried on the hardened concrete were compressive strength test, flexural strength, split tensile strength test for 7 days and 28 days strength determination. For compressive strength and split tensile strength, digital compression testing machine was used and flexural strength two point loading system was employed. The maximum load at failure was taken for strength comparison. To determine the mineralogical properties of RHA X-ray diffraction test was performed. The results are reported.

Mix proportions:-

Water-cement ratio	Cement	Coarse aggregate	Fine aggregate	water	Wood Waste Ash
0.5	394.32 Kg/m³	1168 Kg/m³	680 Kg/m³	197.16 Kg/m³	0 Kg/m³

Three cubes tested for 28days curing:-

Cube-1	350kn
Cube-2	1000kn
Cube-3	800 kn

average compressive strength =716.66KN

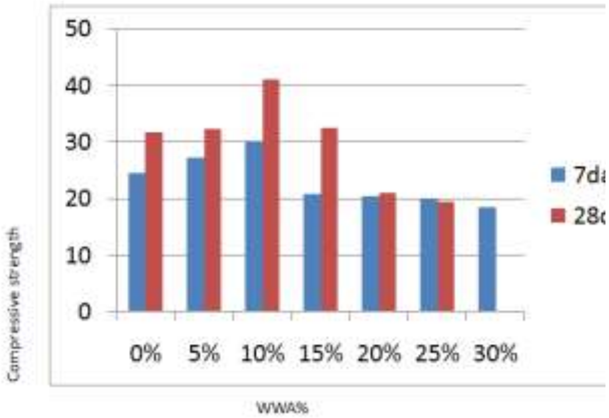
compressive strength @ 28 days

M25 = 716.66/0.15*0.15

= 31.85 mpa M_{30} = 39.25 mpa

S.no	Mix designations	Wood Waste Ash%	Avg load at 7 days	Avg load at 28 days	Compressive Strength 7 days	Compressive Strength 28 days
1	M1	0	550	716.66	24.44	31.85
2	M2	5	613.33	730	27.25	32.44
3	M3	10	683.3	923.33	30.37	41.03
4	M4	15	466.66	733.3	20.74	32.59
5	M5	20	460	473.3	20.44	21.03
6	M6	25	446.6	440	19.85	19.55
7	M7	30	416.6	390	18.51	13.62

COMPRESSIVE STRENGTH



Result and Discussion

The results obtained are in harmony with the findings of Naik et alwho evaluated the physical properties of wood ashes of five different sources and concluded that the unit weight range from 162 kg/m3 to 1376 kg/m3. The low unit weight and specific gravity as compared to conventional cement opens up a possibility of reduction in the unit weight of concrete produced by WA blended cement. Chemical composition data for the cement and WA are also presented. This particular specimen of WA contains 65.30% of silica. The total composition of pozzolanic essential compound namely silica, alumina and ferric is 71.79% which is similar to those of class N and F type pozzolans. This result also very close to the mean value of 72.78% which is the means of the pozzolanic essential compounds as reported by various researchers.

Conclusions

This investigation leads to the following conclusions: (1) According to physical and chemical analysis, the presence of pozzolanic essential compound as required by standards, the presence of much finer particles and hence, larger surface area per particles make WA pozzolanic material. (2) XRD data showed that that WA contains amorphous silica making it fit as cement replacing material due to its high pozzolanic activity. (3) The strength parameters decrease slightly with increase in wood ash content in the concrete when compared to control specimen. However the strength obtained is still higher than the target strength of 20 N/mm2. Also the strength increases with age due to pozzolanic reactions. (4) Thus, use of WA in concrete helps to transform it from an environmental concern to a useful resource for the production of a highly effective alternative cementing material.The statistical regression model of SVM was successfully used to predict the unknown strength parameters. Thus, the application of a computational model in concrete was successfully shown. Recommendation The process employed for generation of wood ash can be improvised as this research employed the wood ash obtained from the uncontrolled burning of saw dust. Quantity and quality of wood ash are dependent on several factors namely combustion, temperatures of the wooden biomass, species of wood from which the ash is obtained and the type of incineration method employed. So, as such any future work must focus on the above factors to produce a more reactive ash by workingout optimum condition for the production of amorphous silica. By using WA in variable amount as replacement of cement in concrete, concrete with high durability and improved strength can be obtained. This novel concrete would certainly decrease environmental problems, product cost and energy depletion.

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