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Original Research Paper

Effect of Wood Waste Ash on the Strength Characteristics of Concrete

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ABSTRACT

The present paper describes the effect of addition of wood waste ash (0-30%) in concrete. Wood ash is an admixture: a pozzolana. Wood ash is generated as a by-product of combustion in wood-fired power plants, paper mills, and other wood burning industries. Wood ash has been added to the concrete in varying percentages ranging from 0 to 30%. The compressive strength and tensile strengths of wood ash concrete was evaluated by conducting laboratory experimentation. The results obtained were compared with reference to M30 grade concrete. The paper presents the various details of experimentation and analysis of results to come up with useful conclusion about the utilization of wood waste ash as an admixture in the concrete.

INTRODUCTION

Cementitious materials have been used by mankind for construction from time immemorial. The every rising functional requirement of the structures and the capacity to resist aggressive elements has necessitated developing new cementitious materials and concrete composites to meet the higher performance and durability criteria. The environmental factors and pressure of utilizing waste materials from industry have also been the major contributory factors in new developments in the field of concrete technology.

Concrete is an artificial material in which the aggregates both fine and coarse are bonded together by the cement when mixed with water. Concrete has unlimited opportunities for innovative applications, design and construction techniques. Its great versatility and relative economy in filling wide range of needs has made it very competitive building material.

With the advancement of technology and increased field of applications of concrete and mortars, the strength workability, durability and other characters of the ordinary concrete need modifications to make it more suitable for specialised situations. Added to this is the necessity to combat the increasing cost and scarcity of cement. Under theses circumstances the use of admixtures is found to be an important alternative solution.

Wood ash is an admixture: a pozzolana. A pozzolana is a material rich in silica and alumina which in itself has little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties. Wood ash is generated as a by-product of combustion in wood-fired power plants, paper mills and other wood burning facilities. Since, wood is a renewable source of energy and environmentally benign friendly material, there will be increased use of wood in energy production in the future. As a result, there will be increased amount of wood ash generation.

The inclusion of wood waste ash as a partial cement replacement material in wood waste ash/OPC blended cement resulted in a delay of cement setting hence the need for longer initial and final setting times of blended cement paste. The effects of setting time delays become more significant with the increase in the level of cement substitutions with wood waste ash (Elinwa & Ejeh 2004, Elinwa & Mahmood 2002, Udoeyo & Dashibil 2002, Abdullahi 2006). Delays in the initial and final setting of cement paste in the presence of wood waste ash is largely due to the dilution of cement content as part of the OPC was used as a substitute with wood waste ash (Elinwa & Ejeh 2004). Elinwa et al. (2008) investigated the effects of partial substitution of cement by wood waste ash in the formulation of self compacting concrete (SCC) and mortar (SCM) mixes. At a constant mix proportion of cement, sand, water binder ratio and dosage of super plasticizer, the mortar spreads of SCM mixes containing wood waste ash (from open burning of sawdust) at a cement replacement level ranging from 0% to 20% of binder weight were observed to undergo consistent reduction from 270mm to 200mm. In addition, the fresh SCM mix flow times were found to increase from 4 s to 18 s.

Rajamma et al. (2009) investigated the compressive strength of cement mortar mixes containing wood waste fly ash obtained from a wood biomass fired power plant. Wood waste fly ash was used as cement replacement material at replacement level of 10, 20 and 30% of total binder weight.

It was observed that mortar mixes with a wood waste fly ash content of 10% exhibited higher 28-day compressive strength but lower flexural strength in comparison with equivalent neat OPC mortar. The use of wood waste fly ash as a partial cement replacement material at higher replacement level of 20 and 30% of total binder weight was observed to reduce 28 day compressive strength relative to equivalent neat OPC mortar mix.

Udoeyo et al. (2006) studied the flexural strength development behaviour of concrete mixes produced with the use of wood waste ash as a partial cement replacement material at varying levels of cement replacement; (0 control concrete), 5, 10, 15, 20, 25 and 30% binder weight. Flexural strengths of concrete specimens produced were recorded at 3, 7, 14, 21 and 28 days. Analysis of the results indicated that at all ages of the concrete, there was an increased level of cement replacement with wood waste ash that resulted in a decreased magnitude of flexural strength.

In view of the research reported, it is essential to study the behaviour of wood waste ash concrete with locally available wood waste ash so that the disposal problems associated with this waste can be minimized and the production of green concrete can be promulgated. In this paper, the compressive and tensile strengths of wood waste ash concrete of M30 grade at various addition levels ranging from 0 to 30% have been investigated experimentally and the results have been analysed.

MATERIALS AND METHODS

Cement: Ordinary Portland cement 53 grade was adopted throughout in carrying out the present investigation. The properties of the cement are given in Table 1.

Sand: Natural river sand available in the nearby source was used in the experimentation. The specific gravity and fineness modulus of sand is 2.64 and 3.77 respectively.

Coarse aggregate: Crushed granite material with 50% passing 20mm and retained on 12.5mm sieve and 50% passing 12.5mm and retained on 10mm sieve was used. Specific gravity of coarse aggregate was 2.75.

Water: Potable tap water available from local source was used for mixing and curing of concrete specimens.

Wood waste ash: Wood waste ash is generated as a by-product of combustion in wood-fired power plants, paper mills, and other wood burning factories. In the present research the wood waste ash used, is detained from 300 microns.

Types of concrete mixes: The experimental scheme comprises tests in compression and split tensile strength. For obtaining compressive strength at 28 and 90 days, 24 (12+12) cube specimens of 150 ×150 × 150mm size were used.

Table 1: Physical properties of cement.

S.No.	Property	Value
1	Fineness of Cement	4.52%
2	Specific Gravity	3.10
3	Normal Consistency	33%
4	Setting Time	
	Initial Setting Time	40 min
	Final Setting Time	6 hours
5	Compressive Strength at	
	3 days	34 N/mm^2
	7 days	44 N/mm^2
	28 days	59 N/mm^2

Table 2: Compressive strengths for various percentages of wood waste ash.

% Wood Ash →	0	10	20	30
28 days Compressive Strength, N/mm^2	49.6	44.3	42.6	39.1
90 days Compressive Strength, N/mm^2	52.3	50.6	44.1	39.6

Table 3: Split tensile strengths for various percentages of wood waste ash.

% Wood Ash →	0	10	20	30
28days Tensile Strength N/mm^2	4.82	4.36	4.05	3.79
90days Tensile Strength N/mm^2	5.37	5.23	4.18	3.82

Twenty four cylindrical specimens with 150mm diameter and 300mm height were cast to find split tensile strength. Four mixes were adopted for the experimental work. In each mix wood ash was added in 0, 10, 20 and 30% by weight of cement. In all the four mixes water/binder 0.49 is kept constant. M30 grade concrete was taken as a reference concrete. The mix proportion arrived for M30 grade concrete as per IS 10262 - 1982 is 1:1.45:2.89 with water cement ratio of 0.49.

Preparation of test specimens: Cubes of size 150 × 150 × 150mm and cylinders of 150mm diameter and 300mm height were cast and tested for determining compressive and split tensile respectively. All the specimens were cured by immersion in water for a normal curing period of 28 days before testing.

Compressive strength test: Compression test on the cubes was conducted on the 2000 kN. AIMIL-make digital compression testing machine. The pressure gauge of the machine indicating the load has a least count of 1 kN. The cube was placed in the compression-testing machine and the load on the cube was applied at a constant rate up to the failure of the specimen, and the ultimate load was noted. The cube compressive strength is calculated as load per unit area and is presented in Table 2. For each mix three specimens were tested and average values are reported.

Split tensile strength test: Split tensile strength test was

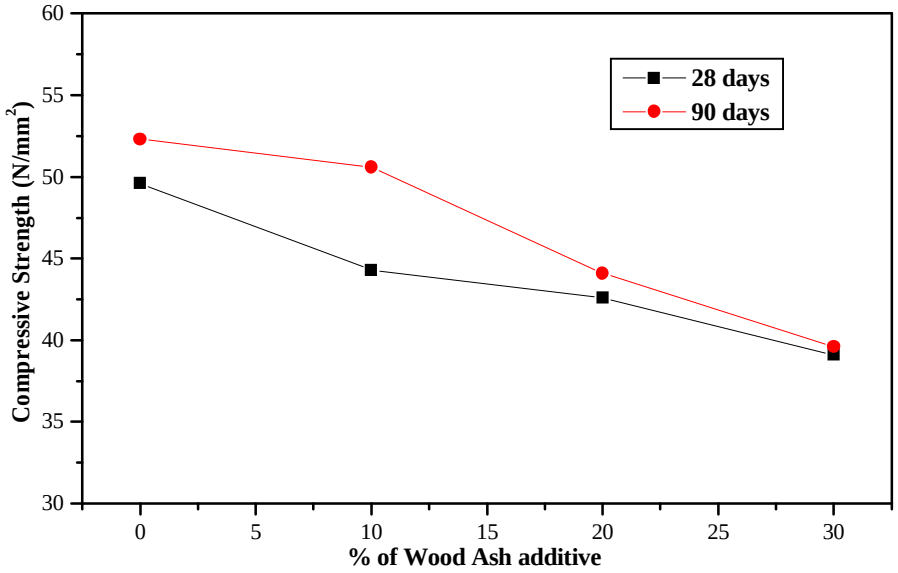

Fig. 1: Compressive strength Vs % wood ash additive.

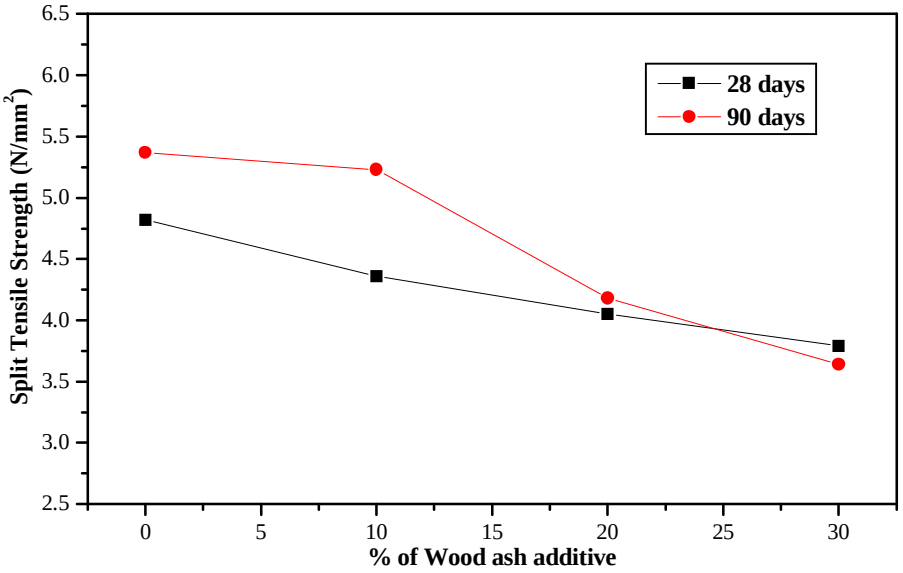

Fig. 2: Split tensile strength Vs % wood ash additive.

conducted on the cylindrical specimen in the 2000 kN capacity AIMIL make digital compression testing machine. The cylinders prepared for testing are 150mm in diameter and 300mm long. After noting the weight of the cylinder, diametrical lines were drawn on the two ends, such that they are in the same axial plane. Then the cylinder is placed on the bottom compression plate of the testing machine and is aligned such that the lines marked on the ends of the specimen are vertical. Then the top compression plate is brought into contact at the top of the cylinder. The load is applied at uniform rate, until the cylinder fails and corresponding load is recorded (P). From this load, the splitting tensile strength was calculated for each specimen from equation (1) and the results are presented in Table 3. For each mix, three specimens were tested and average values are reported.

$$\text{Split tensile strength (MPa)} = \frac{2P}{pDL} \qquad ...(1)$$

Where, D and L are diameter and length of cylinder specimen.

RESULTS AND DISCUSSION

Compressive strength: The performance of wood waste ash concrete in compression is presented in Fig. 1. Comparisons of the strength of wood waste ash concrete with those of the control concrete of corresponding ages show that the strength of wood waste ash concrete is generally less than those of the plain concrete. A possible explanation for this trend is that the wood ash acts more like filler in the matrix than as binder. Compressive strength of wood ash concrete for 0 and 10% levels shows higher strength at 28 and 90 days. This result is indicative of an enhancement in the strength of the concrete within these levels due to a longer period of curing. The test results presented in Table 2 show that there were significant difference at 10% additive level between the 28-day and 90-day strengths. However, when the ash content increased beyond 10%, there existed no statistical difference between both strengths. The reason for no significant differences between both strengths at 20 and 30% additive levels could be due to inadequate water in the mix for the continuation of the weak pozzolanic activity of the ash in the concrete. The improvement in the later-age (90-days) strength up to the 10% additive level may be due to fine-filler effect and the weak pozzolanic activity of the wood waste ash in the concrete. The addition of 10% wood waste ash by weight of cement appears to be the optimum amount that produced the most significant difference between the 28-day and the 90-day strengths.

Split tensile strength: From Fig. 2 it is observed that with the increase in the percentage of wood waste ash addition, the tensile strength decreases both at 28 and 90 days curing when compared to that of plain concrete. When compared to 28 days curing, it is observed that at 90 days curing the tensile strength of wood waste ash concrete increased abruptly at 0 & 10% levels, indicating the improvement in the micro structure of the cement. But at 20 and 30% levels the difference in the increase in the strengths is marginal due to inadequate water in the mix which in turn lead to weak pozzolanic activity in the concrete.

CONCLUSIONS

The effect of addition of wood waste ash on the compression and tensile strengths of M30 concrete has been evaluated in the present study. Wood waste ash if used as an additive in concrete, it can be of great help to reduce its disposal problems paving way for environmental protection. The results of the present study indicate that both compressive and tensile strengths of wood waste ash concrete are quite comparable with plain concrete at 10% levels. The tests showed promising results in that wood waste ash can suitably used as constituent material in the production of structural grade concrete with acceptable strength properties. These findings provide a solution for the waste management problems of wood waste ash and also contribute towards minimizing the consumption of energy intensive hydraulic cement production of greener concrete material supplying the ever growing demand of the construction industry. Hence, incorporation of wood waste ash as cement replacement material in blended cement and concrete will be beneficial not only in environmental terms for concrete material, but also in production costs of the aforesaid material. Hence, it can be concluded that wood waste ash can be effectively used in higher grade concrete also up to 10% by weight of cement.

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