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An Experimental Investigation on the Properties of Fiber Reinforced Concrete with Incorporation of Wood Waste Ash

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ABSTRACT

Cementations 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 cementations 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. The concrete has become so popular and indispensable because of its inherent in concrete brought a revolution in applications of concrete. 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 a by situations. Added to this is the necessity to combat the increasing cost and scarcity of cement. Under these circumstances the use of admixtures is found to be an important alternative solution. Hence an attempt has been made in the present investigation to evaluate the workability, compressive strength, split tensile strength and flexure strength on addition of wood waste ash (0 – 30%) along with crimped steel fibers (0-1%) 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.

Keywords : Admixture, Cementation, Durability, Flexure, Pozzolana, Workability

I. INTRODUCTION

India is the second largest producer of cement on the globe after China. In total, India manufactures 251.2 Million Tons of cement per year. The cement industry in India has received a great impetus from a number of infrastructure projects taken up by the Government of India like road networks and housing facilities. While the Indian cement industry enjoys a phenomenal phase of growth, experts reveal that it is poised towards a highly prosperous future over the very recent years. The annual demand for cement in India is consistently growing at 8-10%. NCAER has estimated after an extensive study that the demand for cement in the country is expected to increase to 244.82 million tons by 2012. At the same time, the demand will be at 311.37 million tonnes if the projections of the road and housing segments are met in reality. Concrete is the world's most consumed man-made material. To produce 1 ton of Portland cement, 1.5 tons of raw materials are needed. These materials include good quality limestone and clay. Therefore, to manufacture 1.5 billion tons of cement annually, at least 2.3 billion tons of raw materials are needed. Over 5-million BTU of energy is needed to produce one tone of cement. In the year 1914, India Cement Company Ltd started cement production in Porbandar with an output of 10,000 tons and a production of 1000 installed capacity. At the time of independence 1947, the installed capacity of cement plants in India was approximately 4.5 million tons and actual production around 3.2 million tons per year. The production of superior quality of Ordinary Portland Cement (OPC) in the country was primarily responsible for introducing the grading system in OPC by Bureau of Indian Standard (BIS) during 1986-87. The other varieties of structural cements, such as sulphate resisting Portland cement, Pozzolana cement and blast furnace slag cement found their way in the improve quality of prompted the structural engineers and major consumers to adopt higher grades of concretes in the construction work. This has been marked difference in the quality of concrete during this period primarily due to the availability of superior quality of cements in the market. The trend is continuing more and more varieties of cements are coming to the markets which help to the consumers to make appropriated grade quality of concrete to meet the specific construction requirement. The high performance fiber reinforced, polymer concrete composites and ready mixed concrete have been progressively introduced for specific applications.

II. NEED FOR PRESENT INVESTIGATION

Though a lot of research is focused in the last decade on use of various admixtures in producing concrete, very little information is available on wood waste ash fiber reinforced concrete. As already mentioned, Wood ash is an admixture: a pozzolana as it is generated as a by-product of combustion in wood-fired power plants, paper mills, and other wood burning factories. Thus this new admixture has lot of potential for use in concrete. Hence, there is need to study the strength and workability characteristics of WWAFRC(Wood waste ash based fiber reinforced concrete).

III. SCOPE OF INVESTIGATION

The scope of present investigation is to study and evaluate the effect of addition of wood waste ash (0, 10, 20 & 30%) and Crimped Steel Fibers (0, 1 & 2%) in concrete. Cubes of standard size 150mmx150mmx150mm were cast and tested for 28 and 90 days compressive strength. Standard cylinders of size 150mm x 300mm were cast and tested for 28days and 90days split tensile strength. Also standard beams of size 500mm x100mm x 100mm were cast and were tested for 28 days and 90 days flexural strength

IV. OBJECTIVES

The specific objectives of the present investigations are as listed below.

→ To conduct feasibility study of producing wood waste ash concrete using Crimped Steel Fibers
→ To evaluate the workability characteristics in terms of compaction factor and vee bee time on addition of wood waste ash (0-30%) along with crimped steel fibers (0-2%)
→ To evaluate the compressive strengths at 28 and 90 days of WWAFRC
→ To evaluate the split tensile strengths at 28 and 90 days of WWAFRC
→ To evaluate the Flexural strengths at 28 and 90 days of WWAFRC

V. TEST PROGRAMME

To evaluate the strength characteristics in terms of compressive, split tensile and flexural strengths, a total of 16 mixes were tried with different percentages of wood waste ash (0,10,20 & 30%) and different percentages of crimped steel fibers (0,1 & 2%). In all mixes the same type of aggregate i.e. crushed granite aggregate; river sand and the same proportion of fine aggregate to total aggregate are used. The relative proportions of cement, coarse aggregate, sand and water are obtained by IS - Code method. M30 is considered as the reference mix.(Appendix-I)

The parameters studies are:

- Percentage of Wood Ash – 0, 10, 20 & 30%.
- Percentage of Crimped Steel Fiber – 0, 1 & 2%.

For each mix, 6 cubes of size 150 x 150 x 150 mm and 6 cylinders of 150 mm diameter & 300 mm height and 6 flexural beams of size 500 x 100 x 100 mm were cast and tested. A sample calculation for determination of weight and volumes is presented in Appendix-II. The test programmed consisted of conducting Compressive tests on Cubes, Split Tensile tests on Cylinders and Flexural strength on beams at 28 and 90 days.

VI. EXPERIMENTAL INVESTIGATION:

Experimental investigation was planned to provide sufficient information about the strength characteristics of wood waste ash concrete fiber reinforced concrete (WWAFRC)

A) Materials:

- Cement: - OPC Cement of 53 grade was used. The Physical Properties of cement are shown in Table 4.1.
- Coarse Aggregate: - Crushed granite metal 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. The details are shown in Table 4.2 and 4.3.
- Fine aggregate: - River sand from local sources was used as fine aggregate. The specific gravity of sand is 2.68. Other details are presented in Table 4.4 and 4.5.
- Water: - Potable fresh water, which is free from concentration of acid and organic substances was used for mixing the concrete.

B) CASTING:

The cubes were cast in steel moulds of inner dimensions of 150 x 150 x 150mm, the cylinders were cast in steel moulds of inner dimensions as 150mm diameter and 300mm height and finally, the flexural beams were cast in steel moulds and timber moulds with inner dimensions of 100 x 100 x 500mm. The materials used in this investigation are cement, fine aggregate, coarse aggregate, crimped round steel fibres and wood waste ash. The cement, sand, coarse aggregate, wood waste ash and crimped steel fibers were mixed thoroughly manually. Approximately 25% of water required is added and mixed thoroughly with a view to obtain uniform mix. After that, the balance of 75% of water was added and mixed thoroughly with a view to obtain uniform mix. Care has to be taken in mixing to avoid balling effect.

VI. WORKABILITY

All the mixes were evaluated for workability in terms of compaction factor and vee bee time.

A) Compaction factor test: The compaction factor test apparatus consists of two hoppers, each in the shape of frustum of a cone and one cylinder. The upper hopper is filled with concrete this being placed gently so that no work is done on the concrete at this stage to produce compaction. The second hopper is smaller than the upper one and is therefore filled to overflowing. The concrete is allowed to fall in to the lower hopper by opening the trap door and then into the cylindrical mould placed at the bottom. Excess concrete across the top of the cylindrical mould is cut and the net weight of the concrete in cylinder is determined. This gives the weight of partially compacted concrete. Then the cylindrical mould is filled with concrete in layers of 5cm depth by compacting each layer fully. The fully compacted weight is then determined.

B) Vee-Bee time test: The Vee-Bee consistometer test is suitable for mixes with low workability whose slump cannot be measured with slump test. Since low water-binder ratios are adopted in the production of HPC, this V-B test is quite suitable to find out the workability. Placing the slump cone inside the metal cylindrical pot of consistometer the slump test is performed. The glass disc attached to the swivel arm is turned and placed on the top of the concrete in the pot. The electrical vibrator is then switched on and simultaneously a stopwatch is started. The vibration is continued till such a time as the conical shape of concrete disappears and the concrete attains a cylindrical shape. This can be judged by observing the glass disc from the top for disappearance of transparency. Immediately when the concrete fully attains a cylindrical shape, the stopwatch is switched off. The time required for the concrete to change from slump cone to cylindrical shape in seconds is known as Vee-Bee degree.

VII. TEST SET UP AND TESTING

A) Cube compressive strength test:

Compression test on the cubes is 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 is applied at a constant rate up to the failure of the specimen and the ultimate load is noted.

B) Split tensile strength:

This test is conducted on 2000 kN AIMIL make digital compression testing machine as shown in Plate No: 4.8. The cylinders prepared for testing are 150 mm in diameter and 300 mm long. After noting the weight of the cylinder, diametrical lines are 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 the load is recorded. From this load, the splitting tensile strength is calculated for each specimen. A sample calculation for computation of split tensile strength is presented in Appendix-III (B). In the present work, this test has been conducted on cylinder specimens after 28 days and 90 days of curing.

C) Flexural strength test:

The test is conducted on a loading frame. The beam element is simply supported on two rollers of 4.5 cm diameter over a span of 450 mm. The element is checked for its alignment longitudinally and adjusted if necessary. Required packing is provided using rubber material. Care was taken to ensure that the two loading points were at the same level. The loading was applied on the specimen through hydraulic jacks and was measured using a 500 kN pre-calibrated proving ring. The load is transmitted to the beam element through the I-section and two 16mm diameter rods spaced at a distance of 300mm. For each increment of loading, the deflections at the center of span are recorded using dial gauges. Continuous observations were made and the cracks were identified with the help of magnifying glass. Well before the ultimate stage, the deflectometers were removed and the process of load application was continued. As the load increased, the cracks are widened and extended to top and finally the specimen collapsed in flexure. At this stage the load is recorded as ultimate load. The flexural strength of the HPC mix is then computed. In the present investigation, this test has been conducted on beam specimens after 28 days and 90 days of curing.

VIII. DISCUSSION OF TEST RESULTS

*WORKABILITY:

Effect of addition of wood waste ash:

The workability of WWAFRC (Wood Waste ash fibre reinforced concrete) mixes has been measured by conducting Compaction factor test and Vee Bee time test. The values of compaction factors and vee bee times obtained from present investigation are presented in the following table. The variations of workability on addition of wood waste ash are presented in below figures.

Table 1 : Workability in terms of Compaction Factor

S.No	% of fiber	Compaction Factor			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0%	0.931	0.874	0.832	0.792
2	1%	0.873	0.852	0.811	0.776
3	2%	0.851	0.834	0.794	0.742

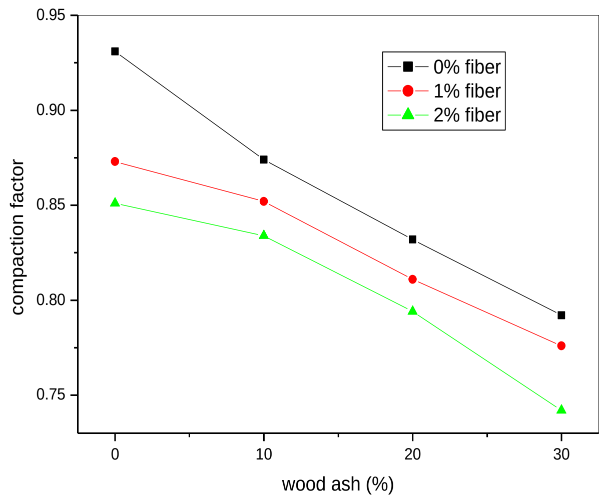


Figure 1 : Compaction Factor vs. % of Wood Waste Ash

Table 2 : Workability in terms of Vee-Bee Time (sec)

S.No	% of fiber	Vee - Bee Time (sec)			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0%	4.5	5.6	6.1	8.2
2	1%	5.3	6.1	7.3	9.4
3	2%	6.2	6.9	8.6	10.5

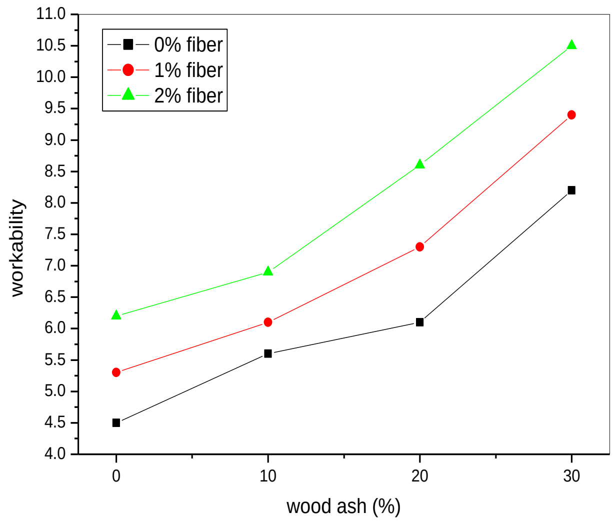


Figure 2 : Vee-Bee Time vs. % of Wood Waste Ash

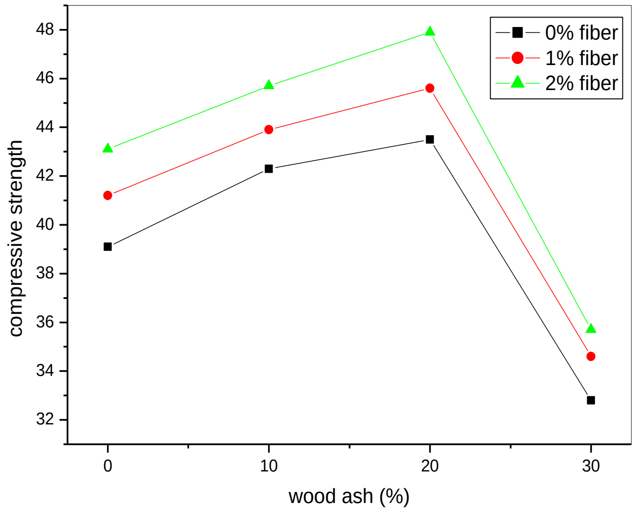
*COMPRESSIVE STRENGTH

Effect of addition of wood Waste ash:

The variation of 28 days and 90days cube compressive strength of WWAFRC mixes are presented in Figures 3(A) & 3 (B) respectively.

Table 3 : 28 days Compressive Strength values in N/mm²

S.No	% of fibre	Compressive Strength (Mpa)			
		0% WWA	**10% WWA**	**20% WWA**	**30% WWA**
1	0%	39.1	42.3	43.5	32.8
2	1%	41.2	43.9	45.6	34.6
3	2%	43.1	45.7	47.9	35.7



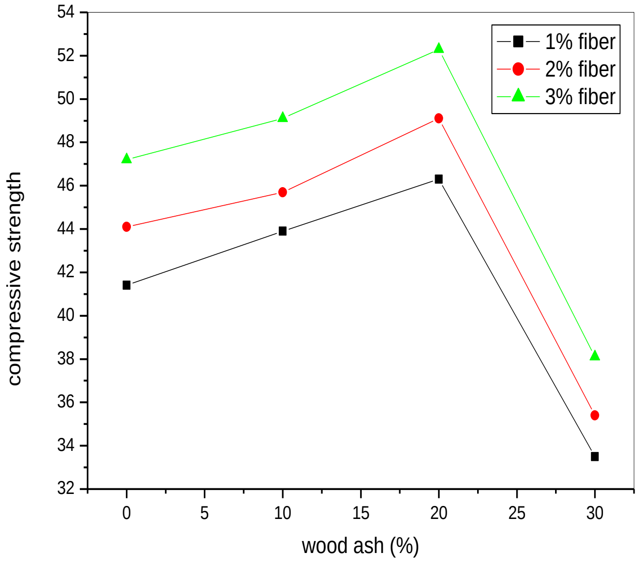


Figure 3 : 90 Days Compressive Strength Vs % of Wood Waste Ash

***SPLIT TENSILE STRENGTH**

Effect of addition of wood waste ash:

The variation of 28 days and 90days Split tensile strength of WWWAFRC mixes are presented in the below figures.

Table 4 : 28 days Split Tensile Strength values in N/mm²

S.No	% of fibre	Split Tensile Strength (Mpa)			
		0% WWA	**10% WWA**	**20% WWA**	**30% WWA**
1	0%	4.37	4.51	4.76	3.68
2	1%	5.31	5.59	5.82	4.49
3	2%	5.67	5.82	6.27	4.77

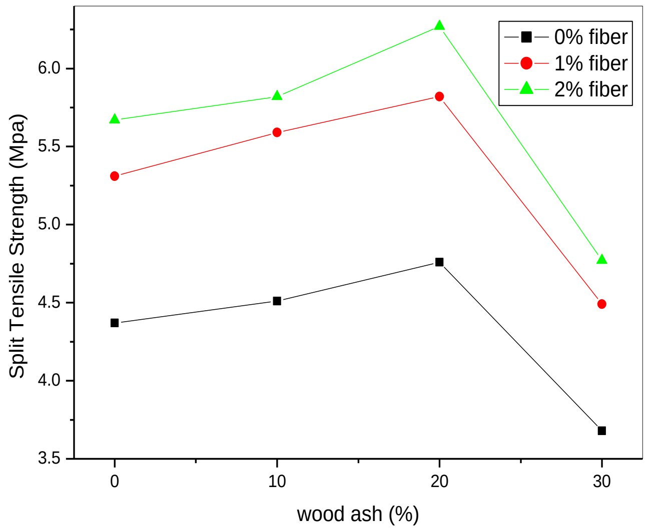


Figure 4: 28 Days Split Tensile Strength Vs % of Wood Waste Ash

Table 5: 90 days Split Tensile Strength values in N/mm^2

S.No	% of fibre	Split Tensile Strength (Mpa)			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0%	4.51	4.68	4.85	3.77
2	1%	5.57	5.86	5.97	4.68
3	2%	6.11	6.25	6.72	5.11

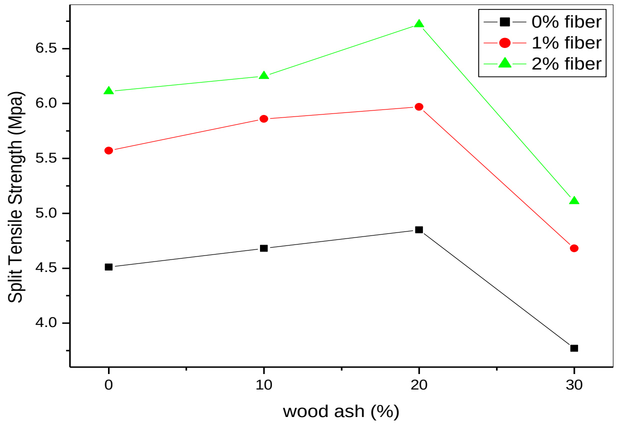


Figure 5: 90 Days Split Tensile Strength Vs % of Wood Waste Ash

Flexural strength

Effect of addition of wood waste ash:

The variation of 28 days and 90days beam flexural strength of WWAFRC mixes are presented in Figure.

Table 6 : 28 days Flexural Strength values in N/mm^2

S.No	% of fibre	Flexural Strength (Mpa)			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0%	5.15	5.45	5.61	4.32
2	1%	6.23	6.51	6.79	5.17
3	2%	6.72	6.99	7.28	5.68

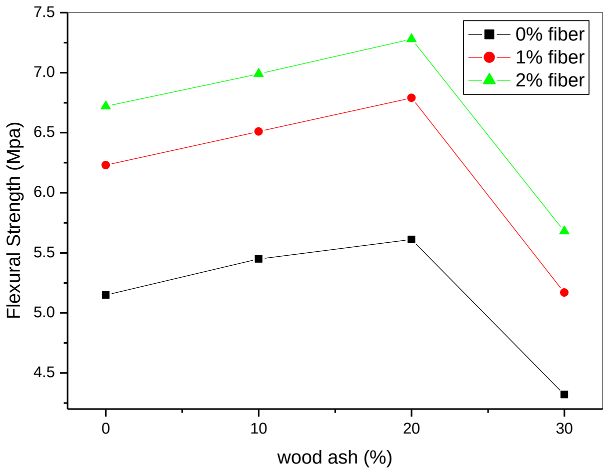


Figure 6 : 28 Days Flexural Strength Vs % of Wood Waste

Table 7: 90 days Flexural Strength values in N/mm^2

S.No	% of fiber	Flexural Strength (Mpa)			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0%	5.36	5.59	5.78	4.47
2	1%	6.41	6.76	7.07	5.39
3	2%	7.26	7.57	7.85	6.12

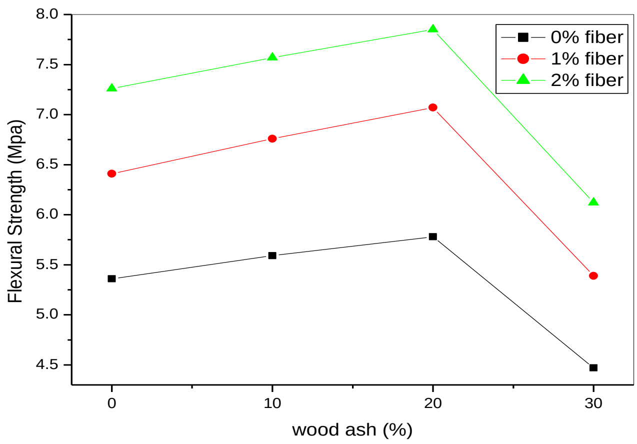


Figure 7 : 90 Days Flexural Strength Vs % of Wood Waste Ash

IX. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions may be drawn from the study on strength characteristics of wood waste ash fibre reinforced concrete properties.

→ The workability of concrete measured from compaction factor degree, as the percentage of wood waste ash and steel fibre increases in mix compaction factor decreases. Hence it can be concluded that with the increase in the wood waste ash content and fiber content workability decreases.

→ The workability of concrete measured from vee-bee degree, as the percentage of wood waste ash and steel fibre increases in mix the vee bee time increases. Hence it can be concluded that with the increase in the wood waste ash content and fiber content workability decreases.

→ From the experimental results, the optimum percentage recommended is 1% steel fiber volume with 20% addition of in wood waste ash achieving maximum benefits in compressive strengths, split tensile strengths and flexural strengths at any age for the characteristics of wood waste ash fibre reinforced concrete.

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