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STUDIES ON STRUCTURAL BEHAVIOUR OF FIBRE REINFORCED CONCRETE

KARASALA MARY RUTH[1], Dr. K.SUNDARA KUMAR[2]

[1]P.G. Scholar in Structural Engineering, Civil Engineering Department
[2]Associate Professor& Head of the Department, Civil Engineering Department
[1,2]Usha Rama College of Engineering & Technology Andhra Pradesh, India

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Abstract:- 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 characteristics. 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. 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. 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.

In this direction, 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. 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 added crimped steel fibre reinforced concrete. The scope of present research is to study the workability in terms of compaction factor of wood waste ash based fiber reinforced concrete and to study the strength characteristics in terms of compressive, split tensile and flexure strengths of wood waste ash based fiber reinforced concrete. Standard cubes of 150 X 150 X 150 mm have been cast and tested for obtaining 28 days compressive strength. Standard cylinders of 150mm diameter and 300 mm height were cast and tested for Split tensile strength. Standard Beams of 500mmx100mmx100mm were cast and tested for Flexural strength. M30 concrete has been used as reference mix. Results were analyzed and optimum percentages of Wood Waste Ash and Crimped Steel Fibres are found to be 20% and 0.75% respectively. Detailed description about the results was presented with help of graphs, and future scope was discussed.

1. INTRODUCTION:

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. Cement and steel are available in the free market and the durability of concrete was guaranteed and was unquestionable. The reinforced concrete has become a common building material because of its inherent strengths such as

- High strength and durability
- Easy design procedures to suit any type of aggressive environmental conditions.
- Modularity to required size and shape
- Resistance to fire.
- Flexibility to extend or reduce without serious efforts and side effects.
- Cracking and damage control.
- Easy maintenance.

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 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.

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 on addition of wood waste ash (0-30%) along with crimped steel fibers (0-1%)
- To evaluate the compressive strengths at 28 days of WWAFRC
- To evaluate the split tensile strengths at 28 days of WWAFRC
- To evaluate the Flexural strengths at 28 days of WWAFRC

METHODOLOGY

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 (0,0.5,0.75 & 1%). 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 strength parameters are studied for the following combinations:

- With percentage of Wood Ash – 0, 10, 20 & 30%.
- With percentage of Crimped Steel Fiber – 0, 0.5, 0.75 & 1%.

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 beams of size 500 x 100 x 100 mm were cast and tested. The test programmed consisted of conducting Compressive tests on Cubes, Split Tensile tests on Cylinders and Flexural strength on beams at 28 days.

MATERIALS USED:

Cement: - OPC Cement of 53-grade was used.
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.
Fine aggregate: - River sand from local sources was used as fine aggregate. The specific gravity of sand is 2.68
Water: - Potable fresh water, which is free from concentration of acid and organic substances was used for mixing the concrete.
Fiber: Steel Fibers is supplied by "STEWOLS INDIA (P) LTD, An ISO 9001: 2008 Company" at Nagpur. The most important parameter describing a fiber is its Aspect ratio. "Aspect ratio" is the length of fiber divided by an equivalent diameter of the fiber, where equivalent diameter is the diameter of the circle with an area equal to the cross sectional area of fiber. The properties of fiber reinforced concrete

are very much affected by the type of fiber. Different types of fibers which have been tried to reinforce concrete are steel, carbon, asbestos, vegetable matter, polypropylene and glass. In the present investigation crimped round fibers used, Aspect ratio of 50

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. For the present study wood waste ash was obtained from the nearby hotels where wood is used as fuel.

RESULTS

Effect of addition of wood waste ash on workability:

The workability of WWA-CSF (Wood Waste Ash-Crimped Steel Fibres) concrete mixes has been measured by conducting Compaction factor test. Workability in terms of Compaction Factor with percentage variation of WWA and CSF are given in Table 1 below. IT can be observed that the compaction factor of WWA-CSF mixes decrease with the increase with the addition of wood waste ash content indicating a decrease in the workability. This is due to the absorption of water from the mix by the wood waste ash.

Table 1: Workability in terms of Compaction Factor

S.No	%of CSF	Compaction Factor			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0.00% CSF	0.920	0.867	0.832	0.790
2	0.50% CSF	0.802	0.834	0.812	0.781
3	0.75% CSF	0.871	0.845	0.812	0.761
4	1.00% CSF	0.843	0.776	0.770	0.741

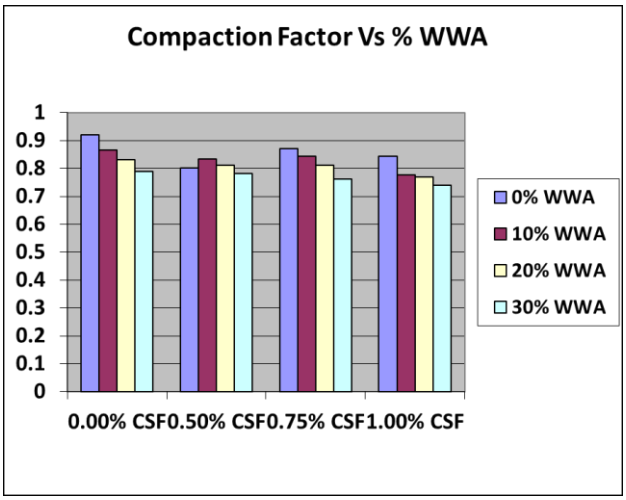

Figure 1: Compaction Factor vs. % of Wood Waste Ash

Effect of percentage of steel fibres on workability:

The variation of compaction factor with the effect of volume of crimped steel fibres. It can be observed that the compaction factor decreases with the increase in the percentage of crimped steel fibres. Thus indicating decrease in the workability with the increase in the crimped steel fibres content. This phenomenon is due to increase in the Water demand for the increase in the fibre volume. The fibres also obstruct the free movement of the concrete mass, and the fluidity of the concrete mix gets decreased.

Effect of addition of wood Waste ash on compressive strength:

The test results obtained from the compression of cubes under the compression test machine are given in the Table 2. The variations of 28 days cube compressive strength of WWA-CSF mixes can be observed that the 28 days compressive strength increases with the increase in the percentage of wood waste ash up to 20% addition level.

Table 2: 28 days Compressive Strength values in N/mm²

S.No	%of CSF	Compaction Factor			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0.00% CSF	38.9	41.1	42.9	33.0
2	0.50% CSF	40.1	43.8	45.6	33.9

3	0.75% CSF	42.9	45.3	48.0	36.7
4	1.00% CSF	41.6	44.8	46.9	35.3

Effect of percentage of steel fibres on compressive strength:

The variation of 28 days cube compressive strength of wood waste ash –crimped steel fibre reinforced mixes are presented in Figures 2. Hence 0.75% of fiber volume can be taken as optimum content. Similar trends were observed even case of WWC mixes on addition of fibres. Thus the effect of addition of fibers is very much similar for both plain concrete and wood waste ash concrete.

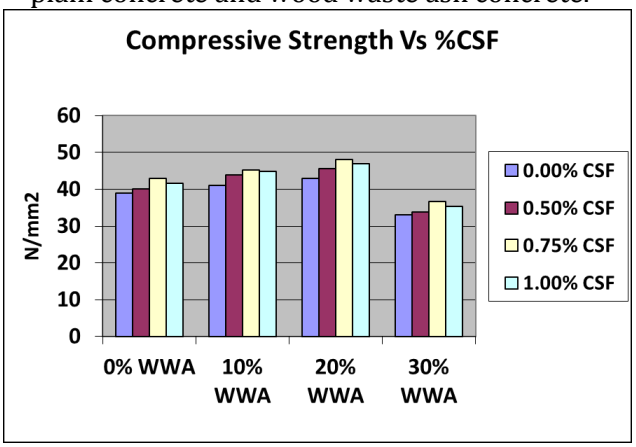

Figure 2: 28 Days Compressive Strength Vs % of Crimped Steel Fiber

Effect of addition of wood waste ash on Split Tensile Strength:

The test results obtained from the split tension test under the compression test machine are given in the Table 3

Table 3: 28 days Split Tensile Strength values in N/mm²

S.No	%of CSF	Compaction Factor			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0.00% CSF	4.26	4.67	4.76	3.65
2	0.50% CSF	5.45	5.61	5.91	4.43
3	0.75% CSF	5.57	5.90	6.33	4.65
4	1.00% CSF	5.32	5.72	6.10	4.45

FLEXURAL STRENGTH

Steel fibres are generally found to have aggregate much greater effect on the flexural strength of SFRC than on either the compressive or tensile strength, with increases of more than 100% having been reported. The increases in flexural strength are particularly sensitive, not only to the fibre volume, but also to the aspect ratio of the fibres, with higher aspect ratio leading to larger strength increases.

Table 4: 28 days Flexural Strength values in N/mm2

S.No	%of CSF	Compaction Factor			
		0% WWA	10% WWA	20% WWA	30% WWA
1	0.00% CSF	5.25	5.56	5.62	4.33
2	0.50% CSF	6.23	6.56	6.81	5.21
3	0.75% CSF	6.67	6.89	7.33	5.72
4	1.00% CSF	6.52	6.67	7.21	5.51

CONCLUSIONS:

The following conclusions may be drawn from the experimental study on the characteristics of concrete with addition of wood waste ash (WWA) and crimped steel fibres (CSF). WWA is added at 0%, 10%, 20% and 30%, where as CSF is added at 0%, 0.5%, 0.75% and 1.0%.

- The workability of concrete with varying quantities of WWA and CSF are measured from compaction factor test. It was clearly understood from the test results that, as the percentage of wood waste ash and crimped steel fibre increases in the mix compaction factor decreases, and hence the workability decreases.
- This is due to the absorption of water from the mix by the WWA and subsequent loss of moisture from the mix, along with the obstruction and frictional resistance

caused by the CSF in the concrete mixture. Hence it can be concluded that with the increase in the WWA and CSF content, workability decreases.

- The compressive strength of concrete cubes made with varying percentages of WWA and CSF were estimated using compression test machine after 28 days curing. From the test results it was found that compressive strength started increasing with addition of WWA and CSF; however this increase was found to be ceased after 20% increase of WWA and 0.75% increase of CSF.
- The increase in compressive strength due to addition of WWA is because of contribution of silica present in WWA to the CSH gel formation. The reduction of compressive strength with increase in percentage of WWA beyond 20% can be interpreted as the loss of water due to absorption by WWA and corresponding loss in degree of workability and hence compactability.
- The increase in compressive strength due to addition of CSF is because of contribution of fibres in bond and arresting the micro-crack development. The reduction of compressive strength with increase in percentage of CSF beyond 0.75 % is due to severe loss of degree of workability and there by poor compactability. It is also very clear that excess fibres will reduce the bond and integrity of the concrete mass.
- The flexural strength of the standard size beams tested under flexure after 28 days curing. The test results show that flexural strength of concrete got increased with increase in percentage of WWA and CSF. But the increase in flexural strength did not continued with increase in WWA and CSF content. Optimum percentages of WWA and CSF are 20% and0.75% respectively.
- Finally it was concluded that addition of WWA and CSF will reduce the workability. But the combined effect of both WWA and CSF will increase the compressive strength, split tensile strength and flexural strength. The optimum percentages of WWA and CSF are 20% and 0.75% respectively.

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