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STUDIES ON STRUCTURAL BEHAVIOUR OF FIBRE REINFORCED CONCRETE

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ABSTRACT: 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. 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.

KEYWORDS: Steel fibres, Admixture, Compressive Strength, Flexural Strength, Split tensile Strength.

I. INTRODUCTION

The current boom in the construction industry has caused an exponential increase in the demand of cement, which is the primary constituent in the production of concrete. The production of cement needs a massive amount of raw material and energy, and at the same time releases carbon dioxide into the atmosphere. Researchers have shown that for every 600 kg of cement, approximately 400 kg of CO_2 is released into the atmosphere. The increasing demand of cement leads to higher rate of environmental degradation and more exploitation of natural resources for raw material. Concrete is the world's most consumed man-made material. Also 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.

Regular concrete is the lay term describing concrete that is produced by following the mixing instructions that are commonly published on packets of cement, typically using sand or other common material as the aggregate, and often mixed in improvised containers. This concrete can be produced to yield a varying strength from about 10 MPa (1450 psi) to about 40 MPa (5800 psi), depending on the purpose, ranging from blinding to structural concrete respectively. Many types of pre-mixed concrete are available which include powdered cement mixed with aggregate, needing only water.

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 wood waste added concrete. Mixing of crimped steel fibres increases the various structural properties which improve its strength and durability. So far there is no work documented on the combined effect of addition of wood waste ash and crimped steel fibres on the strength and other characteristics. Hence it is necessary to study the effect of addition of wood waste ash and crimped steel fibres on the strength and other characteristics.

In this project work an attempt is made to study the properties of concrete like workability as well as compressive strength, split tensile strength, flexural strength of concrete with addition of wood waste ash and crimped steel fibres in varying quantities.

II. MATERIALS USED

Experiments were conducted on concrete prepared by partial replacement of cement by wood waste ash of particle size 75μm at varying percentages and the mix design was prepared.

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. 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. The test programmed consisted of conducting Compressive tests on Cubes, Split Tensile tests on Cylinders and Flexural strength on beams.

CEMENT: Cement is a well-known building material and has occupied an indispensable place in construction works. Different varieties of cements are available in the market and each type is used under certain conditions due to its special properties. The cement commonly used is Portland cement, and the fine and coarse aggregates used are those that are usually obtainable, from nearby sand, gravel or rock deposits. In order to obtain a strong, durable and economical concrete mix, it is necessary to understand the characteristics and behavior of the ingredients. 53 grade OPC is used in this work

AGGREGATES: Aggregates are generally cheaper than cement and impart greater volume stability and durability to concrete. The aggregate is used primarily for the purpose of providing bulk to the concrete. To increase the density of the resulting mix, the aggregate is frequently used in two or more sizes. The aggregates provide about 75% of the body of the concrete and hence its influence is extremely important.

WATER: Generally, cement requires about 3/10 of its weight of water for hydration. Hence the minimum water-cement ratio required is 0.35. But the concrete containing water in this proportion will be very harsh and difficult to place. Additional water is required to lubricate the mix, which makes the concrete workable. This additional water must be kept to the minimum, since too much water reduces the strength of concrete. The water-cement ratio is influenced by the grade of concrete, nature and type of aggregates, the workability and durability. If too much water is added to concrete, the excess water along with cement comes to the surface by capillary action and this cement-water mixture forms a scum or thin layer of chalky material known as laitance this laitance prevents bond formation between the successive layers of concrete and forms a plane of weakness. The excess water may also leak through the joints of the formwork and make the concrete honeycombed. As a rule, the smaller the percentage of water, the stronger is the concrete subject to the condition that the required workability is allowed for.

WOOD WASTE ASH :

Wood Waste Ash (WWA) is the residue generated due to combustion of wood and wood products (chips, saw dust, bark, etc.). It is the inorganic and organic residue remaining after the combustion of wood or unbleached wood fiber. The physical and chemical properties of wood ash vary significantly depending on many factors. The physical and chemical of wood ash, which determining its beneficial uses, are dependent upon the species of the wood ash the combustion methods that include combustion temperature, efficiency of the boiler, and supplementary fuels used.

Typically, wood ash contains carbon in the range of 5-30% (Campbell, 1990). The major elements of wood ash include calcium (7-30%), potassium (3-4%), magnesium (1-2%), manganese (0.3-1.3%), phosphorus (0.3-1.4%) and sodium, (0.2-0.5%). Density of wood ash decreases with increasing carbon content. The chemical and physical properties depend upon the type of wood, combustion temperature, etc. Typically wood burnt for fuel at pulp and paper mills and wood products industries may consist of saw dust, wood chips, bark and saw mill scraps, hard chips rejected from pulping, excess screenings such as sheaves and primary residuals without mixed secondary residuals.

STEEL FIBRES:

Fibre reinforced concrete (FRC) may be defined as a composite materials made with Portland cement, aggregate, and incorporating discrete discontinuous fibres. We know that plain, unreinforced concrete is a brittle material, with a low tensile strength and a low strain capacity. The role of randomly distributes discontinuous fibres is to bridge across the cracks that develop provides some post-cracking “ductility”. If the fibres are sufficiently strong, sufficiently bonded to material, and permit the FRC to carry significant stresses over a relatively large strain capacity in the post-cracking stage. The real contribution of the fibres is to increase the toughness of the concrete, under any type of loading.

Although every type of fibre has been tried out in cement and concrete, not all of them can be effectively and economically used. Each type of fibre has its characteristic properties and limitations. Some of the fibres that could be used are steel fibres, polypropylene, nylons, asbestos, coir, glass and carbon. Fibre is a small piece of reinforcing material possessing certain characteristic properties. They can be circular or flat. The fibre is often described by a convenient parameter called “aspect ratio”. The aspect ratio of the fibre is the ratio of its length to its diameter.

Typical aspect ratio ranges from 30 to 150. Steel fibre is one of the most commonly used fibres. Generally, round fibres are used. The diameter may vary from 0.25 to 0.75 mm. The steel fibre is likely to get rusted and lose some of its strengths. But investigations have shown that the rusting of the fibres takes place only at the surface. Use of steel fibre makes significant improvements in flexural, impact and fatigue strength of concrete; it has been extensively used in various types of structures, particularly for overlays of roads, airfield pavements and bridge decks. Thin shells and plates have also been constructed using steel fibres.

III. 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. For all test specimens, moulds were kept on table vibrator and the concrete was poured into the moulds in three layers by tamping with a tamping rod and the vibration was effected by table vibrator after filling up moulds. The moulds were removed after twenty four hours and the specimens were kept immersed in clean water tank. After curing the specimens in water for a period of 7 days, 28 days the specimens were taken out and allowed for drying under shade before testing. The test programmed consisted of conducting Compressive tests on Cubes, Split Tensile tests on Cylinders and Flexural strength on beams at 28 days.

IV. RESULTS AND DISSUSSION

COMPRESSIVE STRENGTH:

Fibres do little to enhance the static compressive strength of concrete, with increases in strength ranging from essentially nil to perhaps 25%. Even in concrete members that contain conventional reinforcement in addition to the steel fibres, the fibres have little effect on compressive strength. However, the fibres do substantially increase the post-cracking ductility, or energy absorption of the material. The test results obtained from the compression of cubes under the compression test machine are given in the Table below. The variations of 28 days cube compressive strength of WWA-CSF mixes are presented in Figures below. From Figure it 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 1: 28 days Compressive Strength values in N/mm^2

S.No	% of CSF	Compressive Strength (MPa)			
		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

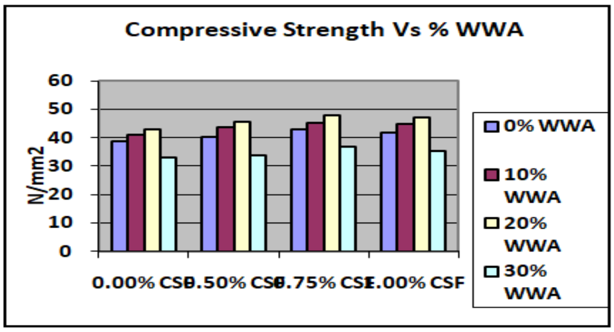

Figure 1 : 28 Days Compressive Strength Vs % of Wood Waste Ash

SPLIT TENSILE STRENGTH

Fibres aligned in the direction of the tensile stress may bring about very large increases in direct tensile strength, as high as 133% for 5% of smooth, straight steel fibres. In the present work crimped steel fibre were used and split tensile strength was tested with varying quantities of WWA and CSF.

Table 2: 28 days Split Tensile Strength values in N/mm^2

S.No	% of CSF	Split Tensile Strength (MPa)			
		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

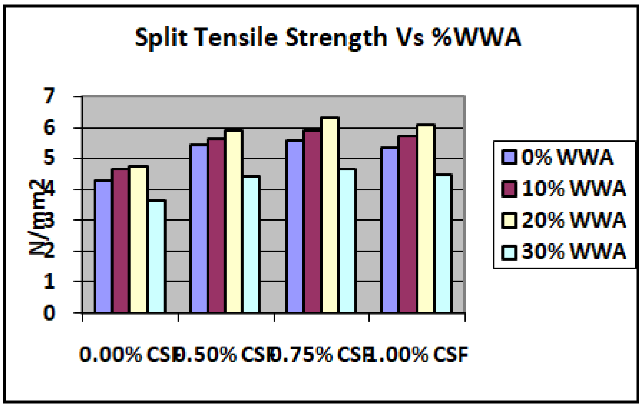

Figure 2: 28 Days Split Tensile Strength Vs % of Wood Waste Ash

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 3: 28 days Flexural Strength values in N/mm^2

S.No	% of CSF	Flexural Strength (Mpa)			
		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

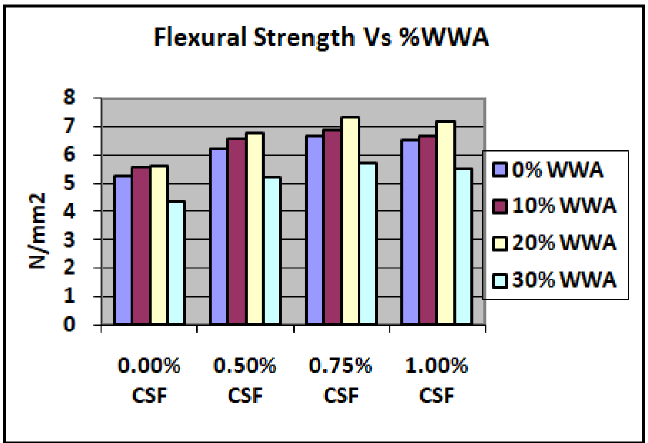

Figure 3: 28 Days Flexural Strength Vs % of Wood Waste Ash

V. 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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