International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 7 ǁ July 2023 ǁ PP. 353-359

Experimental Investigation of Partial Replacement of Cement with Wood Waste Ashand Steel Fibre in the Concrete

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ABSTRACT
The present investigation deals with the study of the effect of addition of wood waste ash (WWA) and crimped steel fibre (CSF) in concrete. Wood ash is the residue produced from the incineration of wood, and its products like chips saw dust and bark for power generation or other uses. This is a bio waste and is used as a pozzolanic material admixed in concrete to increase durability and strength. CSF is produced as a by-product from industrial processes. Commercial production of CSF for use in concrete is also available now-a-days. In the present investigation an attempt is made to evaluate the workability, compressive strength, split tensile strength and flexure strength on addition of 0, 10, 20 and 30% WWA along with CSF of 0%, 0.5%, 1.0% and 1.5% in concrete. Standard cubes of 150 X 150 X 150 mm has been cast and tested for obtaining 28-day compressive strength. Standard cylinders of 150mm diameter and 300 mm height were cast and tested for Split tensile strength. Standard Beams of 500 X100 X100 were cast and tested for Flexural strength. The results obtained show that gradual increase of both WWA & CSF has decreased the workability. However, the compressive strength increased with the increase of WWA up to 20%and increase of CSF up to 0.75%. Similar trend was followed for split tensile strength of cylinders and flexural strength of beams.
KEY WORDS *-Wood waste ash,crimped steel fibre,compression strength,pozzolanic material.*

Date of Submission: 14-07-2023 Date of acceptance: 30-07-2023

I .INTRODUCTION

The rapid development of construction industry has increased the consumption of cement. But the production of cement involves the depletion of natural resources and greenhouse-gas emissions. Also production cost of cement is increasing day by day. Thus, there is a need to search for alternative materials to cement for use in the construction. Continuous efforts were made in the recent past to produce different kinds of cement, suitable for different situations by changing oxide composition and fineness of grinding. With the extensive use of cement, for widely varying conditions, the types of cement that could be made only by varying the relative proportions of the oxide compositions were not found to be sufficient.

Recourses have been taken to add one or two newer materials, known as additives, to the clinker at the time of grinding, or to the use of entirely different basic raw materials in the manufacture of cement. The use of additives, changing chemical composition, and use of different raw materials have resulted in the availability of many types of cements to cater to the need of the construction industries for specific purposes. The most important pozzolana materials are fly ash, silica fume and Metakaolin whose use in cement and concrete is thus likely to be a significant achievement in the development of concrete technology in the coming few decades. Continuous generation of wastes arising from industrial by-products and agricultural residue, create acute environmental problems both in terms of their treatment and disposal. The construction industry has been identified as the one that absorbs the majority of such materials as filler in concrete. Some industrial wastes have been studied for use as supplementary cementing materials such as Fly ash, Silica fume, Pulverized fuel ash, volcanic ash, Rice's husk ash and Corn cob ash.

Wood waste ash is generated as a by-product of combustion in woodfired power plants, paper mills, and other wood burning facilities. Abdullahi determined the properties of wood ash to be used as partial replacement of cement.In order to overcome the problem of brittleness of concrete several research works has been carried out to enhance the properties of concrete such as durability, ductility, flexural strength, fracture toughness, thermal and shock strength, resistance under dynamic, fatigue and impact load by inclusion of fibres in the concrete mixture.

II. LITERATURE REVIEW

1. Youjiang Wang et al. (2000).,

Reviewed the use of different type of recycled fibers such as tire cords/wires, carpet fibers, feather fibers, steel shavings, wood fibers from paper waste and high density polyethylene in concrete. In addition to the advantage that the fibers increase the toughness and durability, use of recycled fibers also helps to reduce the waste and resource conservation. Adding small fraction of fibers helps to resist the crack propagation and crack opening as well as it improves the tensile properties of concrete. Author also presents a review of different kind of recycled fibers such as fibers from carpet waste, used tyres, paper product and other recycled fibers and from the earlier studies conducted, they conclude that recovered material can provide similar reinforcement as original material although the quantity of fiber used may be higher to match the performance. Finally they suggest that the durability study of recycled fibers is an area which is not explored yet.

2. K. Neocleous et al. (2006).,

Studied the design issues for concrete reinforced with steel fibres, including recycled steel fibres recovered from scrap tyres. This paper examined the suitability of existing guideline by RILEM for the flexural design of recycled steel fibre reinforced concrete. They found some fundamental design issues related to the tensile stressstrain 17 behaviour of steel fibre reinforced concrete. On the basis of this, they developed a new model and it was applied for the flexural design of steel fibre reinforced concrete. It is concluded that the model proposed in this study is more conservative and accurate than the RILEM models.

3. G. Centonze et al.(2012).,

Studied the mechanical properties of Steel Fiber Reinforced Concrete (SFRC) and compared it with that of Recycled Steel Fiber Reinforced Concrete (RSFRC). Also the post cracking behavior of concrete were evaluated by conducting four point flexural test. Experiments were conducted by taking same percentage of fibers in SFRC and RSFRC and the results were compared each other and also with that of plain concrete. As the fibers were recovered from different sources, the geometric variation in the diameter and length of the fibers was also taken into account. By conducting flexural test on specimen, the crack mouth opening displacement (CMOD) and crack tip opening displacement (CTOD) were measured. From the results obtained from the compressive, flexural and post cracking behavior of the recycled fiber reinforced concrete, it was clear that the use of recycled steel fiber is a promising application in the field of civil engineering. Authors also suggest to study the technological issues related to fiberproduction and concrete mix preparation.

4. Ratod Vinod Kumar1 , M. Shiva Rama Krishna.(2013).,

In this study the replaced cement with silica fume in the reinforced self compacting concrete with recycled steel fibers and studied its mechanical properties and impact resistance. The combined effect of silica fume andrecycled steel fibers improved the mechanical properties and impact resistance. From the results obtained, a linear equation was also developed. Experiment was performed with different percentage of silica fume replacing cement and reinforced with three different level of fiber volume fraction. Compression test, splitting tensile test, three point bending test and impact test was performed and after the analytical study, empirical equations was developed by regression analysis. Even though the replacement of cement with silica fume and adding recycled steel fibers reduced the workability of concrete, the combined effect of them

5. Antonio Caggiano et al. (2015).,

Studied the experimental and numerical characterization of the bond behavior of steel fibers recovered from waste tires embedded in cementitious matrices. The results of an experimental investigation aimed at understanding the tensile response of the steel fibers and their bond behavior when embedded in cementitious matrices are reported and discussed. Then, an extensive comparison between numerical predictions and the corresponding experimental results of the pullout behavior of recycled steel fibers embedded in concrete is presented for validating and calibrat- ing the model and a satisfactory agreement was found between the both.

6. M. Mastali and A. Dalvand (2016).,

In this study the replaced cement with silica fume in the reinforced self compacting concrete with recycled steel fibers and studied its mechanical properties and impact resistance. The combined effect of silica fume and recycled steel fibers improved the mechanical properties and impact resistance. From the results obtained, a linear equation was also developed. Experiment was performed with different percentage of silica fume replacing cement and reinforced with three different level of fiber volume fraction. Compression test, splitting tensile test, three point bending test and impact test was performed and after the analytical study, empirical equations was developed by regression analysis. Even though the replacement of cement with silica fume and adding recycled steel fibers reduced the workability of concrete, the combined effect of them improved impact resistance and mechanical properties.

III. MATERIALS USED.

1. CEMENT

Ordinary Portland cement (53 Grade) was used for casting all the specimens The type of cement affects the rate of hydration, so that the strengths at 21 early ages can be considerably influenced by the particular cementused. It is also important to ensure compatibility of the chemical and mineral admixtures with cement. Properties of cement physical properties of the cement in the present experimental work are given below.

1.1 Physical Properties of Cement

S.NO	PROPERTY	VALUES
1.	Fineness of cement	225m^2/kg
2.	Specific gravity	3.1
3.	Normal consistency	33%
4.	Setting Time i) Initial setting time ii) Final setting time	45mins6 hours
5.	Compressive strength i) 3days ii) 7days iii) 28days	32N/mm^2 46N/mm^2 58N/mm^2

2. FINE AGGREGATE: -

River sand from local sources was used as the fine aggregate. The specific gravity of sand is 2.68. Properties of Fine Aggregate Physical properties of the fine aggregate used in the present work are given below.

2.1 Physical Properties of Fine Aggregate

S.NO	PROPERTY	VALUES
1.	Specific gravity	2.75
2.	Bulk density i) Loose state ii) Compacted state	14.13KN /mm^3 16.88kN /mm^3
3.	Water Absorption	0.7%
4.	Flakiness index	14.22%
5.	Elongation index	21.33%
6.	Crushing value	21.43%
7.	Impact value	15.5%
8.	Fineness modulus	3.4

3. WATER: -

Potable fresh water, which is free from concentration of acid and organic substances was used for mixing the concrete.

4. COARSE AGGREGATE : -

Crushed granite aggregate with specific gravity of 2.7 and passing through 20 mm sieve and retained on 10 mm was used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

4.1 Physical Properties of Coarse Aggregate

S.NO	PROPERTY	VALUES
1.	Specific Gravity	2.75
2.	Bulk Density i) Loose state ii) Compacted state	15.75KN /m^3 17.05KN /m^3
3.	Grading of sand	Zone – II

5. CRIMPED STEEL FIBRES:-

Steel Fibres are obtained from a local industry. The most important parameter describing a fibre is its Aspect ratio. "Aspect ratio" is the length of fibre divided by an equivalent diameter of the fibre, where the equivalent diameter is the diameter of the circle with an area equal to the crosssectional area of fibre. The properties of fibre reinforced concrete are very much affected by the type of fibre. Different types of fibres which have been tried to reinforce concrete are steel, carbon, asbestos, vegetable matter, polypropylene and glass. In the present investigation crimped round steel fibres of around 25mm length with the aspect ratio of 50 are used. The properties of the CSF used in the present experimentation are given by the supplier and are presented here.

Fig- Crimped steel fibre

5 . 1 Properties of Crimped Steel Fibre

S.NO	PROPERTY	VALUES
1.	Equivalent Diameter,mm	0.15 to 1.00
2.	Specific Gravity, kg/m^3	7840
3.	Tensile Strength, MPa	345 to 3000
4.	Young's Modulus, GPa	200
5.	Ultimate Elongation, %	4 to 10
6.	Thermal Conductivity, 1%	2.74
7.	Aspect Ratio	50 o 100

6. 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. Wood waste ash required for the present experimental investigation was obtained from local hotels wherethe saw dust is used as fuel for cooking. Some of the Physico-chemical properties of thisWWA are adopted from literature and presented here

Figure of wood waste

6.1 Properties of WWA

Physical properties of wood waste ash used in the present experimentalwork are given in the table below.

S.NO	PROPERTY	VALUES
1.	Silicon dioxide (SiO_2)	31.00%
2.	Aluminium oxide (Al_2O_3)	14.40%
3.	Iron oxide (Fe_2O_3)	6.90%
4.	Calcium oxide (CaO)	12.60%
5.	Magnesium oxide (MgO)	0.69%
6.	Potassium Oxide (K_2O)	1.57%
7.	Alkalis	0.89%
8.	Loss of Ignition (1000oC)	34.30
9.	Moisture content	1.6%
10.	Specific gravity	2.56

IV-MIX DESIGN

The mix design for M25 grade concrete were calculated according to IS10262-2019codalprovisions.

MIX PROPOTIONS

Quantity of cement =419kg/m^3
Quantity of Coarse Aggregate = 1175kg/m^3
Quantity of Fine Aggregate = 510 kg/m^3
W/C = 0.4

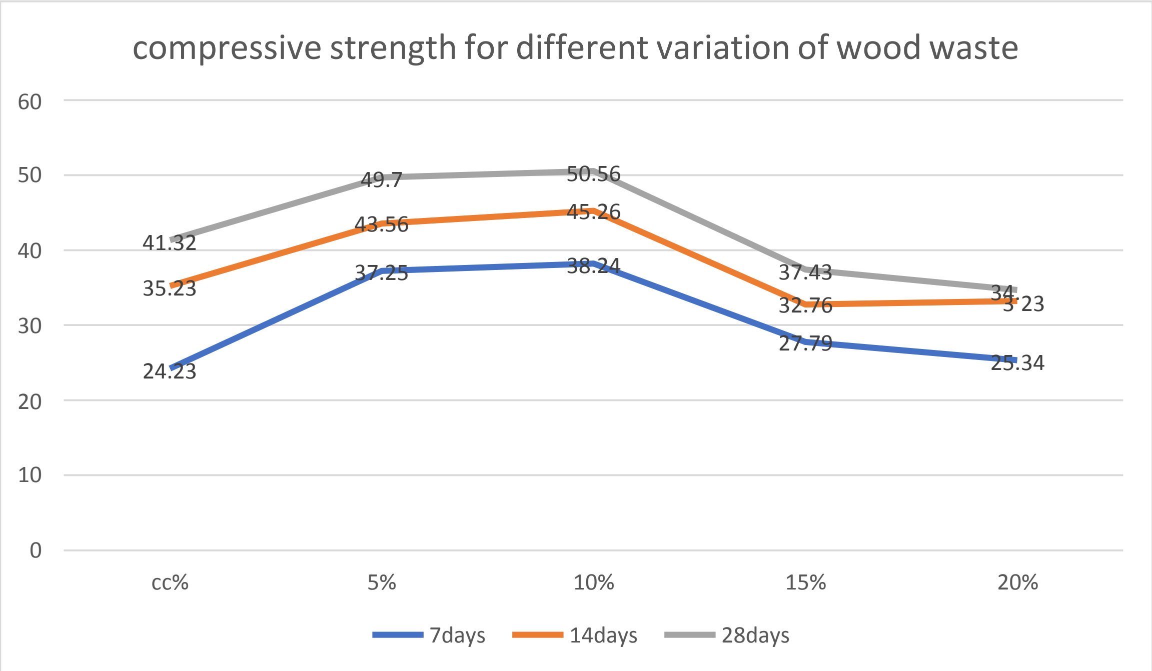
Mix ratio = 1:1:2

V- RESULT AND ANALYSIS

SI.NO	PARTICULARS	COMPRESSIVE STRENGTH(MPa)		
		7DAYS	14DAYS	28DAYS
1.	Conventional concrete	24.23	35.23	41.32
2.	1%SF + 5%WW	37.25	43.56	49.7
3.	1%SF + 10%WW	38.24	45.26	50.56
4.	1%SF + 15%WW	27.79	32.76	37.43
5.	1%SF + 20%WW	25.34	33.23	34.67

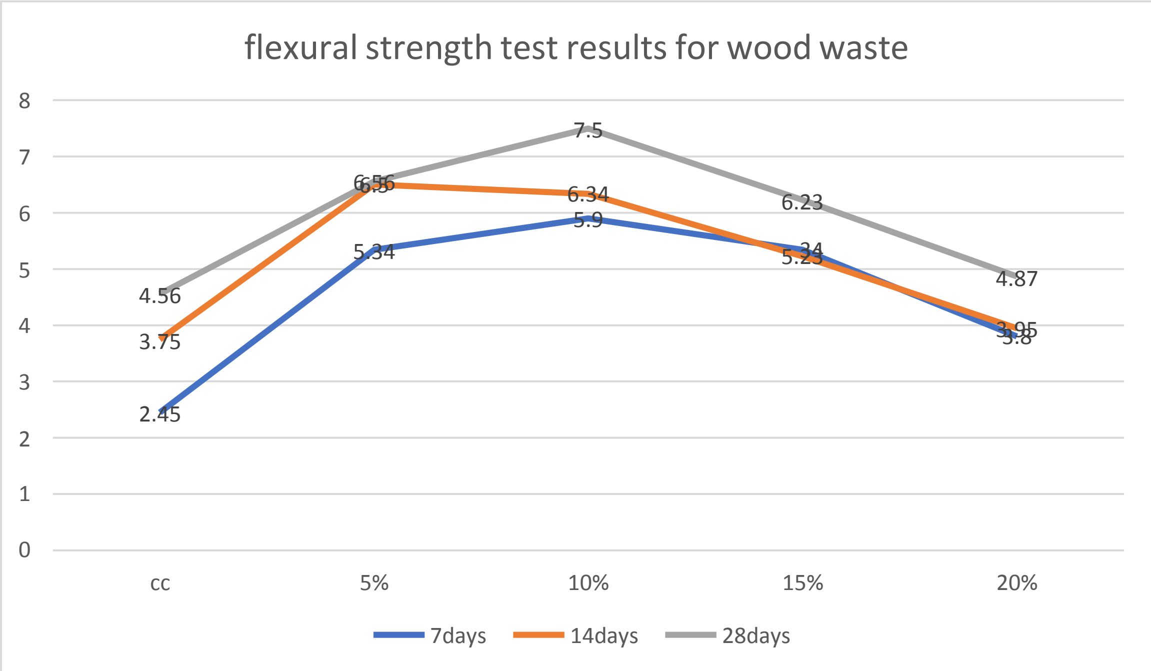
The experimental findings on various design mixtures are discussed in these section compressive strength tests, split tensile strength and flexural strength tests are all included in the results. In this investigation cubes, beam and cylinders of each 18 specimens of each where cast and evaluated over the course of 7days, 14days and 28days. The compression and finding are addressed in more detail in the following sections.

Compressive strength test results for different proportion of wood waste and steel fibre



Flexural strength results for different proportions of wood waste

SI.NO	PARTICULARS	FLEXURAL STRENGTH (MPa)		
		7days	14days	28days
1.	Conventional concrete	2.45	3.75	4.56
2.	1%SF+5%WW	5.34	6.5	6.56
3.	1%SF+10%WW	5.9	6.34	7.5
4.	1%SF+15%WW	5.34	5.23	6.23
5.	1%SF+ 20%WW	3.8	3.95	4.87



VI- CONCLUSION

The major conclusion drawn to through this research work includes the 28days compressive strength of SFRC was found to increase from 16% and 18% with addition of wood waste from 0% to 10% than the conventional concrete. The 28days flexural strength of SFRC was found to be increase from 36% to 46% with addition of wood waste from 0% to 10% of conventional concrete. Thus, the optimum dosage of 10% wood waste will increase the mechanical properties of SFRC when compared to concrete.

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