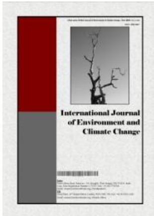

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Physiognomies and Strength Investigation of Concrete Part Blended by Wood Ash

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Cement during its manufacture emits enormous CO_2, and heat to the atmosphere and deteriorate the environment affecting its sustainability. Wood ashes (WA) are the by-products wood based power plants, timber mills as wood dust, barks from forestry, paper industry, and forest fire are simple wastes and are noxious to atmosphere. Present study is investigating the strength and durability of concrete when blended with 0%, 10%, 30%, and 40% wood ash replacing cement to have these wastes effective waste management.
Methodology: The process of investigation is to find the chemical constituents of fly ash, and its suitability to part substitute cement by using X-ray fluorescent spectrometer (XRF), and digital compressive testing machine (CTM) and Universal Testing Machine (UTM) to verify the physical, chemical, and mechanical properties to assess appropriate strength of wood ash blended concrete (WABC).
Results: Strength characteristic at various proportion of mix of (WABC) on testing exhibited decreasing trend on increasing WA percent. The blended concrete exhibited the required compressive strength at 10% addition of WA and after curing for 28days. By utilizing wood ash as cement substitute the environment can be saved from black carbon and further deterioration.

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1. INTRODUCTION

Various industrial wastes and by-products in ash form received from various industrial processes using wood as fuel which degrade the environment by producing CO_2 and other noxious gases. The wood ash waste management is a herculean task. Presently the basic constituent of concrete is cement which during its manufacture produces huge environmental deteriorating gases. Bio-diesel which is a renewable energy source can be extracted from wood scrap and produces huge wood ash wastes and so also from small scale boiler units in manufacturing process. Generally log of hard wood produce more wood ash than the soft wood. Wood ash (WA) have other uses are land filling, soil supplement, and like additive, metal recovery, cement substitute etc. Chee et al, [1], Ottosen et al. [2], Kanan et al. [3]

Many other industrials wastes such as construction and demolition wastes (C& D wastes), red mud, GGBS, fly ash *etc.* are tested for replacing cement in cement concrete production. So to ameliorate the disposal of wood waste, it is preferred to add wood ash as a part substitute of the cementous material, cement after testing the constituent studies, the ingredient distribution within concrete and the strength characteristics like Compressive strength tests, tensile strength tests, split tensile tests Ban et al. [4], Leroy et al. [4], Butt et al. [5], Leroy et al. [6], Faruqi et al. [7].

1.1 Carbon Foot Print and Cement Industry

Science daily has reported cement is one among the silent climate exterminator as it produces huge amount of GHG gas particularly Carbon dioxide during manufacture and concrete production. India consumed of 337MMT during 2018-2019, and predicted to surge up to 550MMT 2025, https://aeee.in/emission-reduction-approaches-for-the-cement-industry/.
The cement industries yields ≈ 5% of global anthropogenic CO2 emissions which constitutes chemical process 50% and 40% from burning clinker @ ≈900kg of CO_2 /MT of cement manufactured (Narayan S,https://www.linkedin.com/pulse/environmental-social-impacts-cement- industries-narayanan/. The environmental impacts are dust, CO_2 and environmental deterioration at quarry sites of limestone.

1.2 Objective of the Research

Review of literature warrants the following repetitive confirmation studies of cement concrete using wood ash as a blending material for cement in cement concrete. They are:

1. To know can wood waste ash (WA) replace concrete of M 20 grade chemically or structurally.
2. Can wood ash blended concrete (WABC) has similar workability like normal CC.
3. Can WABC meet the standards of mechanical properties such as compressive, splitting tensile and flexural strength as plain ordinary equal grade CC M-20.
4. To finalize the optimum doses of WA in % to substitute cement that can satisfy the grade of CC M-20
5. The success of retaining strength of WABC can allure RMC industries and save the environment from worsening.

1.3 Review of Literature

Cement concrete is main construction material of the modern civil architecture. Production of cement involves huge amount of noxious gas and Green House Gases (GHG) gas emissions like NO_X, SO_2, CO, CO_2 and many other noxious gases that pollute the air and health adversities. Attempts are made to replace cement by fly ash, Ground granulated blast furnace slag (GGBS) (Das and Mishra [8], Red mud (Nayak and Mishra [9]) and many other industrial wastes to down surge the use of cement. The wood ash waste is common from nature in the form of rice husk ash, Municipal solid waste ash, can be used to replace partly the cement in concrete. The properly incinerated wood ash has exceptional possibility to be deployed as a pozzolanic admixture that can activate the cementous materials, [10,11].

Many a materials have been tested as part substitute of cement in cement concrete (CC) like fly ash [Siddique, [12], Lahri et al., [13] silica fume [Lee et al. [14], Ahamed et al [15] pulverized fuel ash [Turker et al. [16], Jonida [17] volcanic ash [Kayali [18] rice husk ash

[Bheel et al. [19] and corn cob ash (CCA) [Adesanya et al. [20,21,22]

Rice Husk Ash (RHA) or rice bran ash can be achieved in the process of incineration of rice husk at various temp., (within 700^0C to 1000^0C) evolving fine pozzolana materials having fine silica specific surface area (54 – 81Kg/m^2). This property enhances strength and durability of concrete when partly added. The problem of release of noxious gas to air, disposal of waste, and reduces environmental degradation, Yeoh et al. [23], Chopra et al. [24], Della et al. [25], Bheel et al. [19], Lo, Fang-C et al. [26],

Municipality solid waste ash (MSWA) was tested for its part replacement to cement in concrete. The MSW was burnt either by the method of Refuse-Derived Fuel (DRF) method or mass-burning procedure to yield in an incinerator where large particle remains at bottom and finer in the chimney. The bottom (grate) ash containing calcium (24-27%), silicates and small amount of alumina can be partly substituted to cement as admixture Meheta, [27], Damtoft 28], Lahri et al. [13].

Biomass ash is a by-product in coal based thermal power plant which cannot be disposed easily. It is observed that some of the dried vegetation burned ash has better similarity as pozzolanic materials than coal ash and can replace 20% cement in cement concrete. These wastes excreted from these power plants as by-product have problems of disposal and later deteriorates the environmental. The chemical and strength properties bio ash or coal ash blended cement have common properties and can be substitute cement up to 20% that meet the standards of ASTM C618 specification. The biomass- coal blended cements had similar compressive strengths as coal fly ash cements, Wang et al. [29] , Tkaczewska et al. [30], Garcia et. al. [31].

Several investigators worked on wood ash as supplementary cementous material (SCM) for ordinary or self-compacting concrete (SCC). The optimum part replacement wood ash to cement wasfound to be 15%in the production of ordinary and self-compacting concretes, Abdullah, [32], and Subramaniam et al. [33]. Yang et al. [34] reported that wood ash improves the followability, increases bleeding and subsidence and satisfy the standards imposed in ASTM C114 [35].

From the literature review it reveals that incinerated wood ash can be better substitute retaining the strength and durability mechanical properties of cement concrete. Present research deals with the similarity in chemical constituent, particle distribution at various proportions of mix, mechanical strength properties compressive, and tensile, of concrete.

2. METHODS AND METHODOLOGY

Wood ash when extracted from burning of waste wood has problems of disposal. About 70% are used for land filling ditches and underground places, 20% above the surface in dump yards and management for reuse as additives, fertilizers, metal recovery *etc.*, NCASI bulletin [36], Elinwa et al. [37]. Whether the wood ash can replace cement in conventional ready mix concrete (RMC), then its properties like workability, water absorptivity, compressive strength (comp and split tensile), flexural rigidity, bulk density, durability tests like chloride and sulphate attacks, and acid resistance strengths for the normal and the blended concrete need to be verified. Also chloride and sulphate attack tests were conducted to assess the durability of the WABC. Before use of wood ash to substitute cement in cement concrete (CC), it is required to investigate the similarity in composition of fly ash (proven as a replacement) and wood ash. As the property of wood ash varies depending upon tree size, type of log, age of tree *etc.*, there is necessity of knowing the combustion temperature, and hydrodynamics of the furnace and the type of tree cut to waste. For use of WA as a replacement of cement, the test to be conducted batch leaching of wood waste ash (WWA) which signifies toxicity on leaching of solid waste ash extracted on adding water (ASTM-D3987- [38]

The physical, chemical, compositional, mechanical properties of the WABC at various proportion of substitute by WA were obtained. The various tests for structural test conducted were characteristics like visual, chemical composition, and Mineralogy of wood ash. After finding the suitability to replace cement, the cement concrete (CC) was prepared by substituting cement by WA at various percentage of blending. The physical, chemical, mechanical strengths were to be found for M-20 grade concrete using various Indian standard specifications, ASTM, various codes, and laboratory procedures. The physical, compositional, structural, physical and mechanical properties of WA, Cement, concrete, the instruments and machines used were XRF spectrometer. The tests conducted were for cement concrete. The specific gravity test, consistency test, setting times (Initial & Final), slump test, compaction, compression, tensile and other strength tests were known to find the physical properties of the conventional CC.

The concrete cubes, beams and cylinders specimens were casted of sizes of cubes: 150X150 mm X150mm, cylinders: 150mmX300mm (diameter x length), and beam of size 150mm X150mm X 600mm of numbers of 15 of each variety were casted for testing as per IS: 10086 -1982, reaffirmed 2004 and later in 2008 for cubes and beams and for IS 516 (1959). After casting of the cubes they were submerged in water vat and the different mechanical tests were conducted. The conventional concrete and WABC performances at hardened stage were conducted 7days, 14days, 28days respectively.

2.1 Materials Used and their Properties

The materials for preparation cement concrete (CC) of the experimental works include, cement OPC (53grade), Coarse aggregate (Black hard granite chips), Fine aggregate (river sand), Wood Waste Ash, tap water used for day to day use in CUTM.

2.1.1 Cement

The ordinary cement used is OPC; 53 grade having specific gravity (sp. gr.) as 3.05 (Type I cement), adhering to IS: 12269 of 1987(subsequently reaffirmed, [39]

2.1.2 Coarse aggregate

Coarse black hard Granite stone, machine crushed aggregates of size ranging 12mm t0 20mm agreeing to IS : 2386 (Part I) – 2002 (R),IS383- [40] collected from nearby quarry with sp. gr.2.62, and fineness modulus (FM) 7.08were taken for Grade analysis (Table 3.2). The allowable Fineness Modulus allowed for the coarse aggt is 5.5 to 8.0 http://site. iugaza.edu. ps/hbaker/files/2017/10/Fineness-Modulus.pdf

2.1.3 Fine aggregate

The river sand (quartz, silt free, light grey in colour, and free from organic impurities) was collected from the Mahanadi river and used as fine aggregate confirming IS code 383- [40] The physical properties of the sand used in the research have sp. gr. (2.72), Bulk density (15.45KN/m^3), F.M. (2.80) and particle size variation0.09– 2.0mm.

2.1.4 Wood waste Ash

Wood wastes were collected from a nearby timber saw mill sawing solid wood and were burnt to ashes. In the oven in CUTM lab the ash was put for 5hours for a temperature of 700^{0}C to make the ash fit for blending with cement when cold. VOLATILE MATTER FURNACE; Model: VMF 10/6 Make: CARBOLITE Limited, UNITED KINGDOM was used to generate wood ash at a temperature of 700^{0}C (Fig 1) The physical properties of the wood ash prepared have sp. gr as 2.48 and fineness modulus 6.2%. The chemical constituents of WA observed were XRF spectrometer and the results are in Table 3.

2.1.5 Water

The water used for the WABC is taken from the tap water supplied by the Centurion University of Technology and Management (CUTM), Bhubaneswar campus to its inmates provided for day to day use. The results of water sample were tested by XRF spectrometer as:

3. EXPERIMENTAL SCHEME

3.1 Chemical Similarity between Cement and Wood Ash

At times the carbon content of WA goes from 5–30% (Campbell, [41] and Dave et al. [42]). The chemical constituent is found by using XRF spectrometer of the Centurion University of Technology and management laboratory, and the ingredients of WA is found as: (**Table 1**)

Less powdered ash produced from timber with high carbon content. But the incineration process the density reduced, and chemical and physical properties of the ash changes Mishra [43].

The results received after testing in using XRF spectrometer of OPC Cement tested in the university laboratory is shown in **Fig 3.**

Table 1. The Physical properties of OPC cement of grade 53confirming revised IS: 12269-2004

Characteristics	Fineness	Sp.gr.	Normal consistency	Initial setting time	Final setting time
OPC -53	225m^2/kg	3.1	33%	38mnts	545mnts

Table 2. Gradeanalysis of black hard granite stone chips 12mm-20mm coarse aggregate

Sl. No	I.S.Sievesize in mm	Wt. Retained	Cumulativewt.retained(gms)	Cumulative %retained	% passing
1	80	-	-	-	100%
2	40 or31.8mm	-	-	-	100%
3	20 or 16mm	500gm	500gm	10%	88%
4	10	4300gm	4800gm	96%	4%
6	4.75	200gm	5000gm	100%	-
7	2.36	-	-	100%	-
8	1.18	-	-	100%	-
9	600µ	-	-	100%	-
10	300µ	-	-	100%	-
11	150µ	-	-	100%	-
	Total	5000mm		706.00	

Fineness Modulus (F.M.)=706.00/100= 7.06 (Within permissible limit)

Table 3. The chemical composition of wood ash used for part substitute of cement

Chemicals present	Silicon dioxide	Aluminumoxide	Ferric oxide	Calcium oxide	Magnesiumoxide	PotassiumOxide	Loss on
WA	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Ignition
In (%)	33.04	15.20	9.53	10.63	0.42	2.62	28.27

Fig. 1. The volatile matter furnace Model: VMF 10/6 Make: CARBOLITE Limited, UNITED KINGDOM in Lab for preparing wood ash

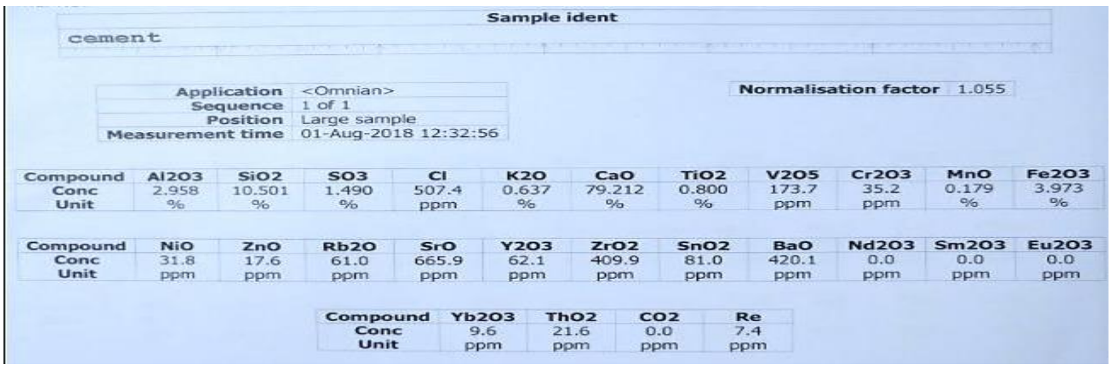
Table 4. The results of tap water used for cement concrete tested from the XRF spectrometer

Parameter	pH	TDS	Alkalinity	Hardness	Sulpher S^{-2}	Chloride Cl^-	Ferric (Fe)
Water at	Scale	mg/l	mg/l	(mg/l)	(ppm)	ppm	ppm
Laboratory	6.65	305	49	135	216	249.6	46.3

Fig. 2. The X-Ray fluorescent spectrometer for chemical analysis (Make: PANalytical B.V.)

Table 5.The elements present in waste wood ash in % range used for part substitute of cement

Element in Timber ash	Calcium (Ca)	Pottassium (K)	Magnesium (Mg)	Sodium (Na)	Phosphorous (P)
Composition(%)	7–33%	3–4%	1 – 2%	0.3–1.3%	0.2-0.5%
Similar elements in OPC Cement	79%	0.64	nil	0.21	Nil



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Compound	Al2O3	SiO2	SO3	Cl	K2O	CaO	TiO2	V2O5	Cr2O3	MnO	Fe2O3
Conc	2.958	10.501	1.490	507.4	0.637	79.212	0.800	173.7	35.2	0.179	3.973
Unit	%	%	%	ppm	%	%	%	ppm	ppm	%	%

Compound	NiO	ZnO	Rb2O	SrO	Y2O3	ZrO2	SnO2	BaO	Nd2O3	Sm2O3	Eu2O3
Conc	31.8	17.6	61.0	665.9	62.1	409.9	81.0	420.1	0.0	0.0	0.0
Unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm

Compound	Yb2O3	ThO2	CO2	Re
Conc	9.6	21.6	0.0	7.4
Unit	ppm	ppm	ppm	ppm

Fig. 3. The XRF test results of OPC cement tested in the laboratory

The WA obtained from barks, and twigs generate more ash in comparison to that is formed from core wood and other inner parts varying (6% to 10%) of the unburnt wood.

3.1.2 Physical Properties of wood ash

Wood ash is generated by ignition of waste pieces/dusts of timber and physical chemical properties, Naik et al. [44] studied some of the physical properties were moisture content found that the range of moisture content was 13 – 22%, specific gravity was 1.65 – 2.48 and Fineness (%) retained by 45 µm sieves were 23-90%. On laboratory test the physical properties were found to be Tests are carried out with reference to Indian standards and the results were as Sp. gr. – 2.13 and bulk density was 768kg/m3 which are within limit and the colour, texture and fineness of WA were also permissible as per Chowdhury et al. [10]

3.2 Need for Study

Since percentage of calcium is higher in ash, so it is pertinent to study the pozzolanic properties of wood ash so that it can partly replace cement in concrete. In addition to reduce the CO2 concentration in air due to emission during cement manufacture, the WABC can make ash waste disposal easy. The wood ash when replace partially conventional OPC cement in commonly used M-20 concrete which does not need any mix design and can be supplied to users as RMC at site. The properties improvement is to be studied in the present research because the WA has properties of thermal resistant and a promising thermal insulation to mass concrete .

4. TESTING METHODS

4.1 Workability of WABC

The IS: 456-2000 [45] was followed for the workability, placing, and compaction of the cement concrete. The slump cone was as per IS: 7320 -1974 [46] have height 30cm, foot diameter 20cm, and truncated top diameter of 10cm. No plasticizers were added for workability of the concrete of M20 grade but the water to cement (W/C) ratio was maintained at 0.5. If super plasticizer (@2%) if would have added, the slump range would have been between 100mmto 160 mm. In the present conventional concrete the slump was 60mm.The various physical tests conducted were consistency, setting time (initial and final), slump test before the concrete were molded. The test results in physical test when the concrete was green were Table 6:

It was observed that the slump values depleted and the slum values reduced to 60mm, 40mm, 32mm, 8mm and 0mm when blended with no cement, 10%, 20%, 30%, and 40% substitutions respectively of cement by incinerated WA. It may be due to low water cement ratio and fine particles WA.

Table 6. Tests to know the physiognomy of cement &concrete OPC 53grader IS: 456-2000 [45]

Tests conducted	Apparatus	Results	To Know	IS Code used
Std Consistency(cement)	Vicat's	32 %	Workability & strength	IS 4031 (Pt4–1988)
Initial setting time (OPC53)	Vicat's	30mnts	Workability	IS 4031-5 (1988):
Final setting time (OPC 53)	Vicat's	585mnts	Workability	IS 4031-5 (1988):
Slump Test	Slump cone	130mm	Workability	IS Code 1199-1959

4.1 Mechanical Properties

The concrete was prepared on mixing with different part substitute of WA by cement at 0% (WABS-0), 10% (WABS-10), 20% (WABS-20), 30% (WABS-30) and 40% (WABS-40) percentage and various mechanical tests were conducted in the laboratory after mixing, transportation, placing, flow, workability and curing of the conventional concrete M-20grade has been done as per IS: 456-2000. The various blends to be tested were as It is proposed to test the mechanical properties of blended concrete such as compressive strength (comp. st.), split tensile test (STT) and Flexural strength (Fl. St.).

4.1.1 The compressive strength (Comp. St.)

The cubes were tested for their compressive strength by the help of either UTM (Universal testing machine) or DCTM (Digital Compression testing machine).The hardened orthodox concrete and WABC of 7, 14, 28 old were made, cured, and tested. The test results are in**Table 7.**

Compressive strength (Comp. St.) of the concrete after curing converts to hardened concrete cubes. The strength of the concrete was ascertained on testing in the laboratory by using the compressive testing machine and Universal Testing Machine (UTM).

The concrete cubical blocks (150mm X150 mm X150mm) were tested by either by the UTM (Universal testing Machine) or DCTM ((Digital compression testing Machine) is measured asper the standard procedure given in IS:516-[47].

Standard concrete cubes of dimensions 150 × 150 × 150 mm are prepared and tested in 1000MT capacity UTM. The compressive strength of average of three specimen showing variation within 10% were considered and reported after 7, 14 and 28 days of curing.

From the results at various mixes it is found that the optimum replacement cement by waste wood ash at 28days curing was found to be optimum at 10% substitute. The less difference is observed for 28 days for R0, R10 and R20. It may be due to lack of lime content in the mix, causing low comp. strength. Fly ash in concrete might have reduced the rate of hydration, and achieved early compressive strength.

4.1.2 Flexural Strength

Flexure strength (Fl St.) was conceded for the conventional concrete of M-20 grade and the strength out as per IS: 516-1959 (revised 2004) employing standard cement concrete beams of size 100mm × 100mm × 500 mm. The concrete beam was tested as simple supported placed as an effective 400 mm span which is loaded at the 1/3 points.

Fig. 4. The UTM and Digital concrete testing and DCTM used for testing the samples

Fig. 5. Curingof specimen cubes, beams and cylinders in curing vat

Table 7. Compressive strength (Replacement cement with waste wood ash)

Slno.	Mix	7 days(N/mm²)	14 days(N/mm²)	28 days(N/mm²)
R0	WABC- 0%	14.71	19.21	22.12
R10	WABC-10%	17.36	22.06	27.02
R20	WABC- 20%	11.93	15.81	18.56
R30	WABC- 30%	7.48	10.69	14.26
R40	WABC- 40%	3.84	6.72	7.89

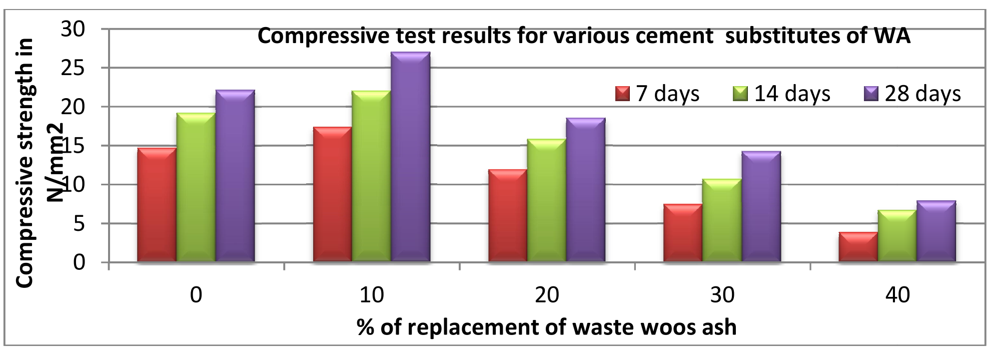

Fig. 5. The compressive strength results at various blending of cement with WA

Table 8. Flexural strength(replacement of cement with wood waste ash)

#.	Mix	7 days(N/mm²)	14 days(N/mm²)	28 days(N/mm²)
R0	WABC- 0	2.68	3.06	3.29
R10	WAC- 10	3.12	3.35	3.31
R20	WAC- 20	2.85	3.21	3.42
R30	WAC- 30	2.44	2.94	3.11
R40	WAC- 40	2.23	2.39	3.02

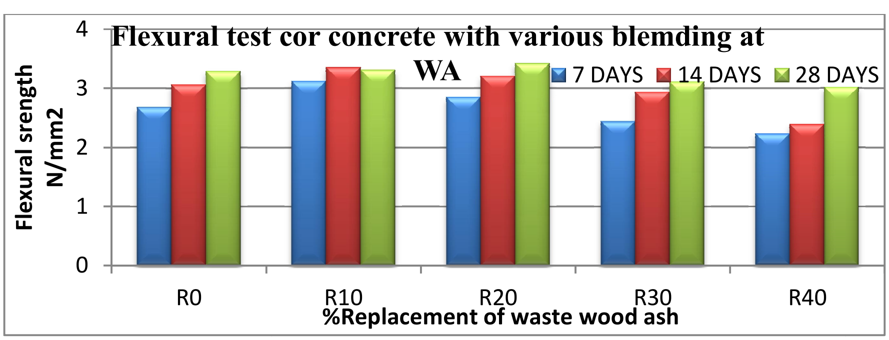

Fig. 6. Flexural strength of concrete at 7, 14 and 28days curing at various substitutes by WA

The Flexural strength results are presented in Table 8, and Fig. 6. From the Flexural strength results as observed from the blended concrete with waste wood ash, it was detected that the conventional mix without waste WA the strength of 3.29 N/mm^{2}after 28 days curing. The Fl. St. of CC was increased to 3.21N/mm^2 and 3.42N/mm^{2}with 10% and 20% replacement of cement by WA after 28 days. With time lapse the fl. St. of the 28days cured blended concrete was increased and for WABC-30 and WABC-40 exhibits diminishing trend.

4.1.3 Split tensile strength

Split tensile test is conducted following the IS: 5816-1999. The cylindrical specimens of 150 mm diameter, and 300 mm height were tested after 7, 14, and 28 days of curing. The sp. tensile strength of average of 3 specimens was conducted and had shown variation with WABC-0, WABC-10, WABC-20, WABC-30, and WABC-40 was tested.

The split (Sp.) tensile strength of the orthodox concrete and the WABC at 10% cement substitute for M-20 concrete the split tensile strength were 3.29N/mm^2 and 3.39N/mm^2 at 28days curing which is found to be increasing. The 28 day split tensile strength for blended concrete was found to be gradually decreasing after WABC 10 onwards up to WABC40.

5. DISCUSSION

The current research is focused on the waste utilization of waste wood ash (WA) replacing cement in concrete to address the environmental issues. WABC were prepared on replacement of cement by WA at various percentages by weight at 0%, 10%, 20%, 30%, and 40% respectively. The present investigation is the impact of WA on physical and mechanical properties of wood waste ash on cement concrete.

Conclusion derived from the results drawn from the present research work.

1. On increasing the fraction of WA on substituting cement in the CC, the workability of concrete decreases, indicates the decrease in slump. It is attributed to higher water demand of WA. It is also inferred that the mix is sensibly cohesive, and workable.

2. On increase in replacement of percentage cement by WA, the performance of CC decreases. It may be due to the high WA demand for water. However, mixing at a 10% replacement level has a reduction of 40 mm in slump value which has sufficient usability for most active functions. The part substitute of cement in the concrete mixes with WA, the workability can be within limit.

3. The increase in WA substitute has reduced the mechanical properties i.e. comp. st., split tensile strength, and flexural strength in the hardened concrete specimen. This is mainly due to the water demand required by WA.

4. The mechanical properties (compressive strength, strength, flexural strength) identified of wood ash have increased by 10% to replace cement with wood ash. Further increases in the level of cement and WA installation have significantly reduced mechanical properties.

5. At 10% replacement level, it is evident that the compressive strength of the WA-containing mixtures is higher than the compressed strength of the concrete at M20 grade, it is concluded that the concrete of the building grade can be produced by 10% installation or cement by WA.

Table 9. Split tensile strength (replacement of with wood waste ash)

Slno.	Mix	7 days(N/mm²)	14 days(N/mm²)	28 days(N/mm²)
R0	WABC-0	2.68	3.06	3.29
R10	WABC-10	2.72	3.11	3.39
R20	WABC-20	2.38	2.75	3.02
R30	WABC-30	2.22	2.54	2.89
R40	WABC-40	1.97	1.98	2.37

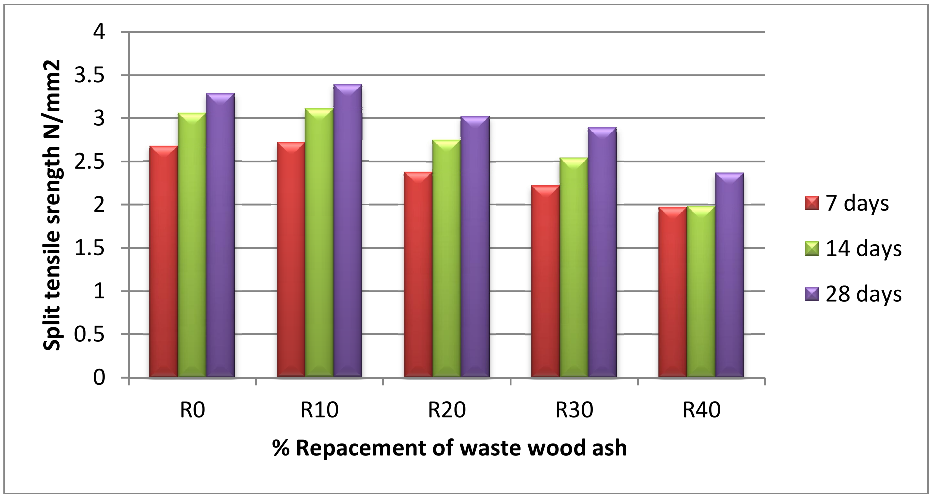

Fig. 7. Graphical presentation of Split tensile strength versus replacement of waste wood ash

Table 10. Comparison of strength of WABC by various investigators

Investigator	Year	% blend WA (Wt.)	Conditions	Reference
Ghorpade V. G.	2012	10%	M-30 grade CC	Ghrpade et al. [49]
Viet-Anh Vu et al.	2019	30%	Mech. properties decrease, Heat capacity increase	Vu et al. [11]
Ambili R et al	2019	07%	OPC 43 grade, M-20, Comp. strength increases by 13%	Ambili R et al. [48]
Raheem, A. A.,	2019	10% + 1.5% Nanosilica	Investigation of Workability & Comp. Strength of WACC Containing Nanosilica	Raheem, A.A. et al. [50]
Hamid, Z et al.,	2020	10%	M-25; admixture add increase the workability of concrete mix	Hamid, et al. [51]
Ikotun, B.D.,	2021	10%/ +2% nanoTiO2	Water absorption, workability and strength improved	Ikotun, B.D., et al. [52]
Dash Smruti S.	2021	10%	M-20grade, workability and strength improved	Present study

6. CONCLUSION

The search for the improvement on the strength characteristics of WA blended CC at various substitutes; it is found that there can be performance of improved strength behaviour of concrete. Under the constraints of pandemics further studies like durability tastes, making self-compacted concrete, use of plasticizers, blending with others wastes like GGBS, silica fume, wood ash, red mud, or marble powder. The result reveals that at 10% WA substitute of cement, the results like comp. stress, split tensile test and flexural test results are improved at optimum replacement of waste wood ash by cement. The ready mix concrete industries can use WABC at appropriate places to moderate the present carbon foot print.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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