EXPERIMENTAL INVESTIGATION ON STRENGTH PROPERTIES OF CONCRETE BY USING WASTE (WOOD ASH AND CRUMB RUBBER)

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Abstract - *The main objective of this project is to study the effects of wood ash and crumb rubber in partial replacement with cement and fine aggregates respectively. Scanning on to the current trend, the demand for renewable energy resources and diversifying current methods of energy production has been seen increasing with a wider intent. As the production of cement is continuously increasing, this leads to the depletion of limestone which is a natural resource indeed. In order to conserve the limestone in nature the reduction of cement production is essential. This project deals with the utilization of an alternative material, wood ash as a partial replacement of cement. Similarly cutting off sand requirement by partially replacing fine aggregates with crumb rubber. Wood ash replaces 8%,12%,14% by weight of cement and crumb rubber by a constant 8% by weight of fine aggregates in concrete. The workability properties such as slump test and mechanical strength properties such as compressive, split tensile and flexural strength are determined and were compared with control M-20 mix. Moreover, the dumping of these materials in the land will turn the land into waste land. These materials pose a threat to our nature by turning the land into waste land. Our aim is to work onto the ways of developing out a concrete, more economical with not much variable strength and property.*

***Key Words*: Wood Ash, Crumb Rubber, Renewable Energy, Cement, Limestone, Fine aggregates, Workability properties, slump test, compaction factor test, mechanical properties, compressive strength, split tensile strength and flexural strength.**

1. INTRODUCTION

Concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement or cement paste that hardens over time most frequently a lime-based cement binder, such as Portland cement, but sometimes with other hydraulic cements, such as a calcium aluminate cement. It is usually distinguished from other in non-cementations concrete all binding some form of aggregate together, including asphalt concrete with a bitumen binder which is used for roads and polymer concretes that use polymers as a binder. When aggregate is mixed with dry cement and water, the mixture forms a slurry that is easily poured and moulded into the respective shape. Concrete is used for many purposes, including basic foundations, superstructures, wastewater treatment, water treatment facilities, parking structures, floor construction and exterior surfaces. Along with concrete, the form systems have evolved to allow for more efficient placement, large quantity placement and architectural finish features that may be desired.

1.1 CEMENT

Cement is one of the major constituents in the manufacture of concrete. Since the demand for cement is increasing day by day the cost of the cement also raises. Since limestone which constitutes the major part of the cement is one of the natural raw material.
The production of the cement leads. to the depletion of the lime stone from the nature. So, in order to conserve our precious natural resources like limestone it is necessary to replace the cement with some other materials which is having the same properties as that of the cement.

1.2 WOOD ASH

Wood Ash which can be utilized in the construction field as a substitute for the cement is the best way for the disposal of such type of materials.
Depletion of natural resources is now a common phenomenon in developing nations like India. It is due to rapid urbanization and industrialization. As an impact of this, people have begun researching for the suitable other alternative materials in order to preserve some other natural resources for the future generation.
The characteristics properties of concrete such as compressive strength, tensile strength and durability test using the mix made by replacing cement with WOOD ASH as well as sand with CRUMB RUBBER were reviewed in the present work.

1.3 SAND

Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type: i.e., a soil containing more than 85 percent sand-sized particles by mass. Sand is a non-renewable resource over human timescales, and sand suitable for making concrete is in high demand. For this reason, the best alternative M sand is introduced.

By comparison with natural aggregate, lightweight aggregate has lower density and higher absorption rate due to several unique properties. The engineering properties of lightweight concrete are also different to normal concrete.

Lightweight concrete structures have many advantages, such as high strength for the same weight ratio, good tensile strain, low thermal conductivity, and improved noise and heat insulation properties [22,23]. However, because of the internal pores, moisture in the cement paste can easily be absorbed by the lightweight aggregate, resulting in poor workability and strength of lightweight concrete. The impact of seismic forces on the structure is proportional to the structural weight. Lightweight aggregate is often used to reduce the structural weight and reduce the damage caused to a structure by an earthquake [24]. Excavation and backfilling are necessary in many engineering facilities and construction. The quality of backfilled earth directly affects the safety of engineering facilities when used in the structure load-bearing layer, the surrounding backfilling or regional land preparation [25].

1.4 CRUMB RUBBER

Controlled low strength material (CLSM) is a self-compacting concrete with lower strength and commonly used as a backfill in situ due to its better load-bearing capabilities. The composition of CLSM is usually from any industrial by products, such as fly ash, foundry sand, waste tires; cement kiln dust, and flue gas desulfurization materials [26–28]. This study used reservoir silt to make lightweight aggregate and replace sand with waste tires in the making of CLSM, which is expected to bring significant benefits to the environment. Modifications of construction materials having an important during a building sector 16 atoms have been there for made in the building material industry to put to use waste material product example worn out Tyres into useful and cost effective item success in this regard will contribute to the production of waste material dumping problems by utilising the waste material as raw material for other products the waste problem considered Add one of the most crucial problem facing the word as a source of environmental pollution it is considered as a direct form in pollution that include the negative effect on the health by increasing the diseases vector percentage of Old image in resulted from production transfer and uses process and general are translated things and sources that the owner of the producer wants to dispose or must dispose to prevent the risk on the health of the women and save the environment in general The proposal presents an experimental study of effect of use of solid waste material in concrete by volume variation of crumb rubber. one of the important tyre remains is waste ideas which have been classified as a part of municipal solid waste which is generated from the increase of vehicle ownership and traffic volume within the Palestinian territory which eventually will increase the production of tires.

2. LITERATURE REVIEW

Pranav S. Dhakulkar et.al studied the properties of concrete with cement replaced with Wood Ash. The Wood Ash has been chemically and physically characterised and partially replaced in the ratio of 5%,10%, 15%, 20% and 25% by weight of cement concrete. The experiment was carried out by using M25 mix with 0.5 water cement ratio. The incorporation of wood ash as partial replacement of cement decreases the slump of concrete. Workability of the concrete is decreases with increase in wood ash content. The strength properties such as compressive strength, split tensile strength and flexural strength at the age of 7, 14, 28 days are evaluated and studied. The test result indicates that the strength of concrete increase up to 15% of Wood Ash replacement with cement. [1]

Amrutha Sebastian et.al studied the mechanical properties of Wood Ash concrete replaced in the ratios 3%, 5% and 8% by weight of Portland Pozzolanic cement (PPC). The strength properties such as compressive strength, split tensile strength and flexural strength at the age of 7 and 28 days are evaluated and studied. The 7th day compressive strength of all three percentages satisfied the requirement. 3% and 5% replacement of Wood Ash by weight of cement satisfied all the strength. But, 5% replacement is more economic. The workability is found to decrease with increase the Wood Ash content. The Wood Ash is pozzolanic in nature. So, it used as partial replacement with cement.[2]

Topcu (1995)3, investigated the consequences of pressure tests led on normal and RUBBER treated concrete and watched that the compressive strength of standard cement gotten from 3D shape tests is higher than that acquired from barrel tests. In any case, the outcomes for rubber treated cements out of the blue demonstrated the turn around15. This shows the mechanical strength of rubber treated mixture is extraordinarily influenced by the size, extent, and surface of RUBBER particles and the sort of concrete utilized as a part of such mixture. [3]

Neil N. Eldin (1993)2, broke down the aftereffects of compressive and part rigid qualities on RUBBER treated cement following 7 and 28 days curing and watched that there was slightest change in the compressive and RUBBER qualities between the seventh and twenty eighth day, when the coarse totals were supplanted by rubber chips by an expansive volume i.e., for the examples containing 75% and 100% tire chips. Decrease of up to 85% of compressive and half of RUBBER was watched when the coarse total was supplanted by RUBBER. A littler decrease was watched when sand was supplanted by piece rubber. The examples showed high limit with regards to retaining plastic vitality under both pressure and strain loadings 13-14. [4]

Relangi Sai Krishna Supretha, D. Venkateswarlu, Divya Anusha Naidu, Concrete is playing a significant role in the growth of infrastructural and industrial segments for many decades. But concrete is not an environmentally- friendly material due to its destructive resource consuming nature. The basis of this research is to investigate the effects of using recycled materials in varying amounts on the fresh and hardened properties of concrete. The recycled materials used in this study are Ground granulated blast furnace slag (GGBS) and recycled concrete aggregates. GGBS was used as partial cement replacement and recycled aggregates as replacement for fine and coarse aggregate. The basic properties of natural and recycled aggregate were determined. The mix design was done to obtain a concrete mix (control mix) of grade M40. Mixes were prepared by replacing 40, 50 and 60% of natural aggregates with recycled aggregates. Then its fresh and mechanical properties were determined along with control mix. From test results concrete with 50% replacement of aggregate with recycled aggregates shows adequate strength compared to control mix. Mixes were prepared by replacing 40, 50 and 60% of cement with GGBS together with 50% replacement of recycled aggregates. From test results concrete with 40% and 50% replacement of cement with GGBS together with S0% replacement of recycled aggregates shows adequate strength compared to control mix. [5]

3. MATERIAL PROPERTIES AND TESTS

The materials used in the making of concrete mix are ordinary Portland cement, fine aggregate, coarse aggregate, water, crumb rubber and wood ash. The properties of each of these materials contribute to the quality of concrete produced. For the present study, the material test for various materials were conducted as specified in the relevant IS codes.

3.1 CEMENT

Ordinary Portland Cement 43 grade purchased from Coimbatore was used for this study. This is one of the most widely used one in the construction industry. It improves the mechanical strength properties of concrete. For this research work Ordinary Portland cement of 43 grade having specific gravity - 3.13, and 3% fineness and standard consistency 33 is used.

Table 1: Properties of Cement.

SI. No	Property of cement	Observed Values
1.	Grade of cement	OPC 43
2.	Specific gravity	3.13
3.	Cement Fineness	3%
4.	Initial setting time	78 Min.
5.	Final setting time	253 Min.

3.2 COARSE AGGREGATE

Coarse aggregates of 16mm and 20mm size is used in this work. The properties of the coarse aggregate used in a concrete mixture affects the modulus for a few reasons. One property is the modulus of elasticity of the coarse aggregate, A higher aggregate modulus will result in a concrete having a higher modulus. As expected, a lightweight aggregate will have a lower modulus than the mortar paste. Conversely, a strong aggregate produces a concrete that is stronger than the mortar paste. In tests, concrete containing a higher percent of coarse aggregate resulted in a higher elastic modulus. As stated earlier, this is due to the aggregate being stronger than the mortar.

The particle shape of the aggregate contributes to the effectiveness of producing a high-performance concrete crushed rock creates a much better bond between the paste and the aggregate than a gravel does. However, the aggregate mortar bond may be more important in flexure tests than in compression tests.

Table- 2: Sieve Analysis Result of Coarse Aggregate

Sieve Size - mm	% Fineness
4.75	98.3
2.36	95.3
1.18	80.4
0.6	53.6
0.3	10.3
0.15	0.5
pan	0

Table- 3: Material Properties of Coarse Aggregate

Sl. No.	Properties	Observed values
1.	Specific gravity	2.92
2.	Fineness modulus	3.18
3.	Maximum size of Aggregate	20mm
4.	Bulk density	1.671 g/cm^3
5.	Water Absorption	0.5%
6.	Void ratio	0.7

3.3 FINE AGGREGATE

The manufactured sand has required gradation of fines, physical properties such as shape, smooth surface textures and consistency which makes it the best sand suitable for construction. These physical properties of sand provide greater strength to the concrete by reducing segregation, bleeding, honeycombing, voids and capillary.

Thus, required grade of sand for the given purpose helps the concrete fill voids between coarse aggregates and makes concrete more compact and denser. Thus, increasing the strength of concrete. The sieve analysis is performed on M sand is shown in table 4. and Material properties of M sand is shown in table 5.

Table- 4: Sieve Analysis Result of m-sand

Sieve Size - mm	% Fineness
4.75	98.3
2.36	95.3
1.18	80.4
0.6	53.6
0.3	10.3
0.15	0.5
pan	0

Table- 5: Material Properties of m-sand

Sl. No	Properties	Observed values
1.	Specific gravity	2.34
2.	Fineness modulus	3.65
3.	Grading zone	Zone II
4.	Bulk density	1.208 g/cm^3
5.	Void ratio	0.536
6.	Water absorption	1%

3.4 WOOD ASH

Wood ash prepared from uncontrolled burning of wood obtained from the industry is studied for its suitability as partial replacement for cement in conventional concrete. The wood ash will adversely affect the workability of concrete. The water requirement increases with increasing wood ash content. It has high calcium oxide content. During the hydration reaction calcium oxide will react with cement and form C-S-H gel provide better strength to the concrete. Wood ash is a residue powder that left after the combustion of wood. Wood is generally used in industries for heat generation. The temperature of combustion have profound effect the ash properties. Wood ash prepared from uncontrolled burning of wood obtained from the industry is studied for its suitability as partial replacement for cement in conventional concrete.

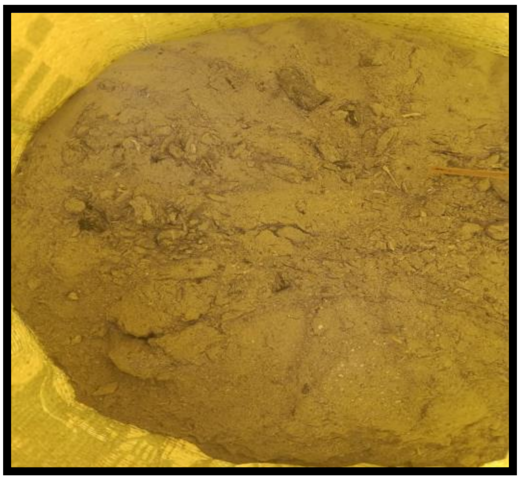

Fig -1: Wood Ash

Table- 6: Chemical Composition of Wood Ash

Sl. No	Particulates	Percentage
1.	CaO	47
2.	SiO_2	37
3.	MgO	8.7
4.	Al_2O_3	5.3
5.	Fe_2O_3	1.53
6.	K_2O	1.2

Table- 7: Properties of different types of pozzolans as defined by ASTM C618 [5]

Properties	Class F Type pozzolan	Class C Type pozzolan	Wood ash
Min SiO_2 + Al_2O_3 + Fe_2O (%)	70	50	50.4
Max Na_2O + 0.658 K_2O	1.5	1.5	0.7895
Max loss of ignition	6	6	2.48

The wood ash is Class C type pozzolan. So, it has pozzolanic and cementitious property.

Table – 8: Properties of Wood Ash

Sl. No	Properties	Observed Values
1.	Specific gravity	2.14
2.	Normal consistency	34.6%
3.	Initial setting time	125min
4.	Final setting time	328 min
5.	Fineness	4%

3.5 CRUMB RUBBER

The Crumb Rubber used in this research is processing with a Grinding Machine and granulator having a 4.75mm nominal maximum size. The crumb rubber is treated by sieving to get on gradation close to that of a typical sand.

Fig -2: Crumb Rubber

Table -9: Physical Properties of Crumb Rubber

Sl. No	Property	Range
1	Specific Gravity	0.52 – 1.2
2	Bulk Density	522 – 1264 Kg/$m3$

4. CALCULATION OF MATERIALS

4.1 CUBICAL MOULD:

Required Amount of Water = 0.47 Litre
Required Amount of Coarse Aggregate = 4.253 Kg
Required Amount of Fine Aggregate @

- 8% Crump Rubber = 1.891 Kg
- Crump Rubber = 0.1644 Kg

Required Amount of Cement @

- 0% Wood Ash = 1.361 Kg
- 8% Wood Ash = 1.2521 Kg
  Amount Of 8% Wood Ash = 0.1089 Kg
- 12% Wood Ash = 1.198 Kg
  Amount Of 12% Wood Ash = 0.1632 Kg
- 14% Wood Ash = 1.17 Kg
  Amount Of 14% Wood Ash = 0.191 Kg

4.2 CYLINDRICAL MOULD:

Required Amount of Water = 0.72 Litre
Required Amount of Coarse Aggregate = 6.6796 Kg
Required Amount of Fine Aggregate @
8% Crump Rubber = 2.9697 Kg
Crump Rubber = 0.25824 Kg

Required Amount of Cement @

- 0% Wood Ash = 2.1369 Kg
  WA =0kg
- 8% Wood Ash = 1.9659 Kg
  WA = 0.171kg
- 12% Wood Ash = 1.881Kg
  WA = 0.2564kg
- 14% Wood Ash = 1.8377 Kg
  WA = 0.2992kg

4.3 BEAM

Required Amount of Water = 1.575 L

Required Amount of Coarse Aggregate = 14.175 Kg

Required Amount of Fine Aggregate @

- 8% Crump Rubber = 6.303 Kg
- Crump Rubber = 0.5481 Kg

Required Amount of Cement @

- 0% Wood Ash = 4.536 Kg
- 8% Wood Ash = 4.173 Kg

  Amount Of 8% Wood Ash = 0.363 Kg

- 12% Wood Ash = 3.995 Kg

  Amount Of 12% Wood Ash = 0.544 Kg

- 14% Wood Ash = 3.901 Kg

  Amount Of 14% Wood Ash = 0.6350 Kg

4.4 TOTAL MATERIALS USED:

Cement required = 15+24+17 = 56 Kg
Fine aggregate required = 22.7+36+25.5 = 85 Kg
Coarse aggregate required = 52+80.5+56.7 = 190 Kg
Wood ash required = 1.389+2.1798+1.542 = 5.11 Kg i.e., 6Kg
Crump rubber required = 1.98+3.2+2.2 = 7.38 Kg i.e., 8 Kg

5. RESULT & DISCUSSION:

5.1 COMPRESSIVE STRENGTH TEST

For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Fig -3: COMPRESSIVE STRENGTH TEST

Table -10: Results of Compressive Strength Test

Cement Content in %	Sand Content %	Waste Content %		Compressive strength after respective curing periods		
		Wood Ash	Crumb Rubber	7 days	14 days	28 days
100	100	0	0	12.57	17.68	19.82
92	92	8	8	9.46	16.7	20.08
88	92	12	8	8.71	12.04	15.02
86	92	14	8	7.2	13.06	13.86

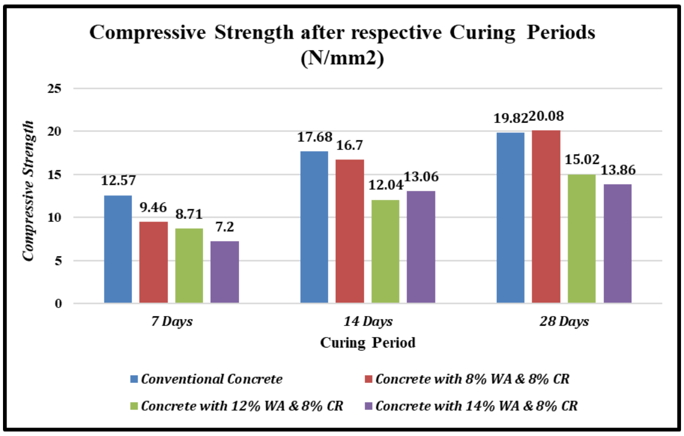

Chart -1: Compressive Strength after respective curing periods.

5.2 SPLIT TENSILE TEST

Initially, take the wet specimen from water after 7, 28 of curing, or any desired age at which tensile strength to be estimated. Then, wipe out water from the surface of specimen. After that, draw diametrical lines on the two ends of the Specimen to ensure that they are on the same axial place.

Next, record the weight and dimension of the specimen. Set the compression testing machine for the required range Place plywood strip on the lower plate and place the specimen. Align the specimen so that the lines marked on the ends are vertical and centred over the bottom plate. Place the other plywood strip above the specimen.

Bring down the upper plate so that it just touch the plywood strip. Apply the load continuously without shock at a rate within the range 0.7 to L4 MPa/min (1.2 to 2.4 MPa/min based on IS 5816 1999) finally, note down the breaking load.

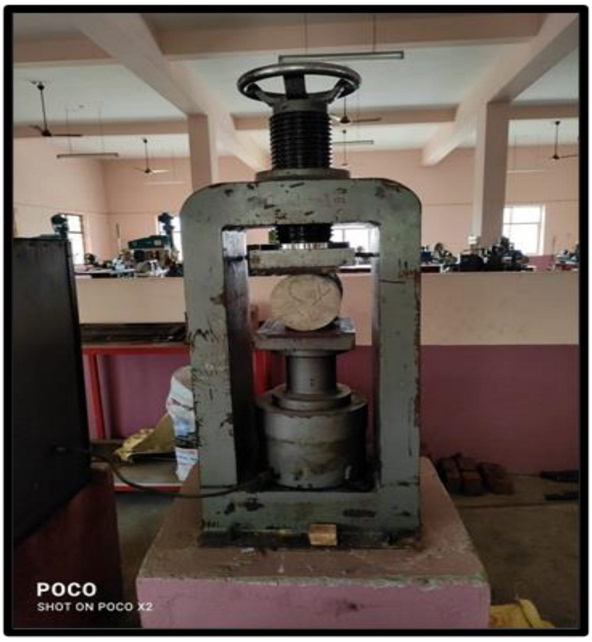

Fig – 4: SPLIT TENSILE TEST

Table -11: Results of Split Tensile Test

Cement Content in %	Sand Content %	Waste Content %		Tensile strength after respective curing periods		
		Wood Ash	Crumb Rubber	7 days	14 days	28 days
100	100	0	0	1.58	2.80	4.612
92	92	8	8	1.05	2.97	4.73
88	92	12	8	0.76	0.93	1.67
86	92	14	8	0.87	0.9	1.95

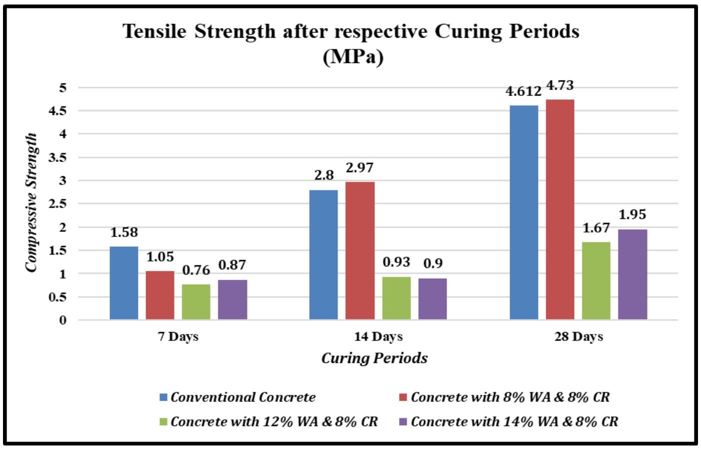

Chart -2: Tensile Strength after respective curing periods.

5.3 FLEXURAL STRENTH TEST

Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire cross section of the beam mould and throughout the depth of each layer. Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers. Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e., span) shall be 3d and the distance between the inner rollers shall be d. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic. The specimen stored in water shall be tested immediately on removal from water, whilst they are still wet. The test specimen shall be placed in the machine correctly centred with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading. The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

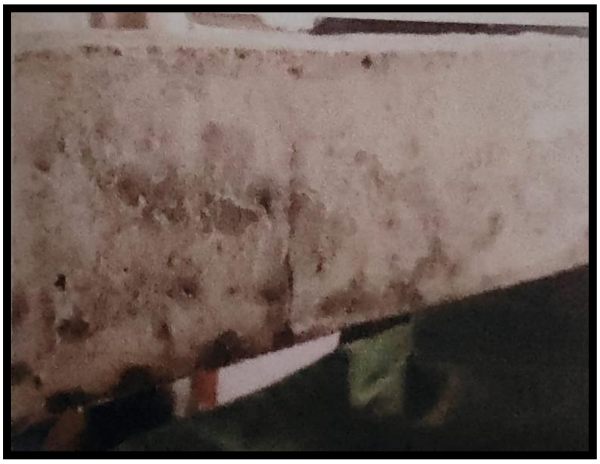

Fig -5: FLEXURAL STRENGTH TEST

Table -12: Results of Flexural Strength Test

Cement Content in %	Sand Content %	Waste Content %		Flexural strength after respective curing periods		
		Wood Ash	Crumb Rubber	7 days	14 days	28 days
100	100	0	0	2.57	2.97	3.13
92	92	8	8	1.45	2.13	3.2
88	92	12	8	1.96	2.51	2.9
86	92	14	8	2.22	2.72	2.89

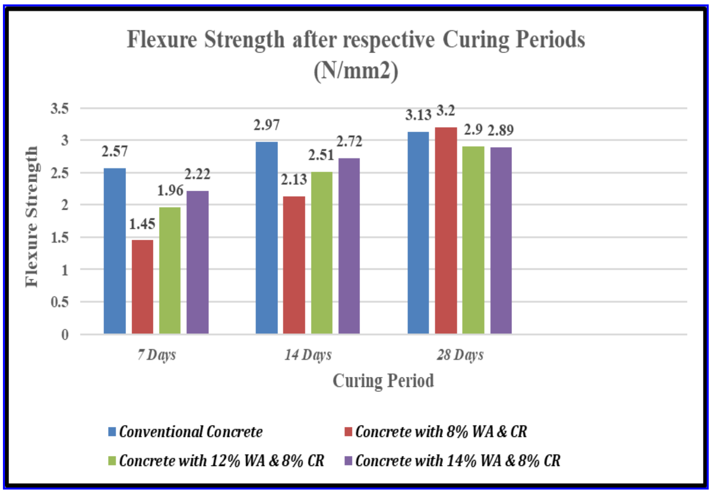

Chart -3: Flexure Strength after respective curing periods.

6. CONCLUSIONS

From this experimental study we can conclude that the main ingredient of the concrete, i.e., Cement can be replaced by using the waste (Wood Ash & Crumb Rubber). This is inferred from the following points

- If we replace the Cement in the Concrete by 12% as well as 14% Wood Ash, then this concrete exhibits Compressive Strength less than that of the Conventional Concrete. From this, we can conclude that this design mix of concrete cannot be used to reduce the quantity of cement usage in the construction field.
- If we replace the Cement in the Concrete by 8% Wood Ash, then this concrete exhibits Compressive Strength more than that of the Conventional Concrete. From this, we can conclude that this design mix of concrete can be used to reduce the quantity of cement usage in the construction field.
- Use of 8% Crumb Rubber has been well utilised to decrease the cracks and shrinks and keep up the pace with the excess water absorption troubles which could have been caused with the addition of wood ash.

It is evident from the above observations that Residential as well as Industrial wastes (Wood Ash & Crumb Rubber) obtained, can replace cement as well as fine aggregate to a

certain percentage in the Concrete Manufacturing Process in the Civil Engineering.
Wood ash contains amorphous silica making it fit as cement replacing material due to its high pozzolanic activity. The strength parameters decrease slightly with increase in wood ash content in the concrete when compared to control specimen.
However, the strength obtained is still higher than the target strength.
Also, the strength increases with age due to pozzolanic reactions.
Thus, the use of Wood Ash & Crumb Rubber in concrete helps to transform it from an environmental concern to a useful resource for the production of a highly effective alternative material in Concrete.

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