Experimental study on properties of concrete by replacing cement with wood ash

Submitted in partial fulfillment of the requirement

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MASTER OF TECHNOLOGY

in

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by

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Transforming Education Transforming India

School of Civil Engineering

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2016

DECLARATION

I, Harish Vij (11210338), a student of Master of Technology in Civil Engineering under department of Structural Engineering of Lovely Professional University, Punjab, hereby affirm that this dissertation report titled **"Experimental study on properties of concrete by replacing cement with wood ash"** contains information thoroughly researched and printed by my own and is genuine and true.

This research study does not, to the best of my knowledge, contain any information which has been already studied and published for the award of the same degree either in this university or any other university.

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Date:

Place: Lovely Professional University

Harish Vij

Registration No:- 11210338

CERTIFICATE

This is to certify that Harish Vij (11210338), have successfully finished this dissertation project report titled **"Experimental study on properties of concrete by replacing cement with wood ash"** supervised and guided by me. I can state with affirmation that this study is the product of his exclusive and genuine investigation and study. No part of this written report has ever been published for the same degree at any University.

The project report is fit for submission and is qualified for the partial fulfillment of the conditions for the award of Master of Technology in Civil Engineering in Lovely Professional University, Phagwara.

Mr. Anshul Garg
Assistant Proffessor
Supervisor

ACKNOWLEDGEMENT

The contentment and euphoria that come with the successful accomplishment of any work would not be complete without mentioning the people whose continuous assistance and support made it possible. I would like to present before you my dissertation work which is a result studied with a blend of both research and knowledge.

I would like to firstly express my heartfelt appreciation to my supervisor Mr. Anshul Garg for his valuable guidance. His continuous encouragement and support has always been a motivation. I thank him for his valuable effort, time, and help.

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ABSTRACT

Construction industry is one of the rapidly increasing industries in the present time. As the countries are becoming more developed, the demand for building of major buildings and structures is increasing rapidly. And due to this, there is an increasing demand of conventional construction materials. But, because these materials are costly and are also not so easily available, the need to use alternative materials of construction arises. We can fulfill this by adding and/or replacing various admixtures to the mix of concrete. The admixtures can be chemical admixtures or mineral admixtures. Some mineral admixtures are wastes materials like Rice Husk Ash, Fly Ash, Wood Ash, Waste Glass, and etcetera. Some chemical admixtures can be calcium chloride, sodium chloride, and polyethylene glycol 400 (PEG-400) to name a few.

A detailed observation of strength properties of concrete like compression, tension, flexural, curing, and workability of concrete is presented in this study course.

There are a number of tests involved in this research work. By partial replacement of cement by waste material, i.e., Wood Ash; is done by replacing the cement in percentages of 5%, 10%, 15% and 20% of the total weight of M25 mix.

All the tests and results were conducted and compared under the Indian standard codes IS 10262-2009 and IS 456-2000.

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CHAPTER 1

INTRODUCTION

1.1 General.

The word Concrete is derived from the Latin word Concreteus, which consists of two terms; “con” (together) and "crescer’’(to grow). Concrete is a enormously used building material consisting of cementing material, fine aggregates, coarse aggregates and needed amount of water, where the fine aggregate usually is natural sand. The major component of concrete is cement. The cement, generally Portland cement binds the aggregates together. Aggregates are generally coarse gravel or crushed rocks as limestone, or granite, along with a fine aggregate like sand. Many admixtures are used to varying properties. In the end water is added to this dry mixture which helps in providing shape, make it solid and provide strength. The process of hardening and strengthening with the help of chemical reaction is known as hydration. Water react with cement and make a bond with other materials and hence making a very hard stone like material. Concrete is good at compression and bad at tension so reinforcement are added to concrete.

All concrete structures undergo cracking to some level. This might be because of shrinkage and tension. These days to get high strength concrete we use admixtures to make it economic and efficient.

1.2 A brief introduction on wastes.

Different operations lead to formation of different types of wastes. Wastes can have any generation source like from poultry houses, farms, mills, industries, household, factories, hospitals, agricultural wastes etc. Many of wastes generated from these sources cause only pollution to the environment, so instead of disposing the wastes there is an increasing interest in using them in different fields. In the field of construction engineering, wastes are utilized as supplementary cementitious materials. The common pozzolans such as Fly Ash and Rice Husk Ash (RHA) produced from agricultural industries have been studied by researchers in the development and use of blended cements which not only improves the properties of the concrete but it also reduces the cost and has a positive effect on environment like reducing carbon dioxide emission. Apart from the two wastes materials, many other materials containing silica and alumina may be pozzolanic and can be used for various purposes. But of all the wastes that are generated as a result of burning some sort of fuels. Wood ash has been identified as having a great potential for using as an alternative cement material, by some percentage, as it is easily available and, on burning, produces ash which contains silica.

1.3 Selection of material.

Selection of material for making high strength concrete should be done carefully, after proper inspection.

1.3.1 Cement

Cement is a binder material which binds others materials of the concrete. Romans, who used the term opus cementicium was made from crushed rock with burnt lime as binder. Cement of 43 grade OPC has been used which is easily available in market. Portland cement is most widely used type of cement around the globe. It is formed by heating limestone.

Table 1: Constituents of Cement

Compound	Formula
Calcium oxide (Lime)	CaO
Iron Oxide	Fe_2O_3
Silicon dioxide (Silica)	SiO_2
Aluminum Oxide (Alumina)	Al_2O_3
Water	H_2O
Sulfate	SO_3

1.3.2 Aggregates

Aggregates are an important material for concrete since it occupies 70-80% of volume in concrete. It includes gravel, sand, broken stones etc. Coarse and fine aggregates have been used for the mix.

1.3.2.1 Coarse Aggregates

Aggregate that retain above 4.75mm sieve are termed as coarse aggregates. Natural sand, and gravel are mined to be used as aggregates. They can be broadly classified depending on their surface texture, shape, unit weight, source etc. They are durable and can bear a good amount of load. Selection of aggregate should be done properly considering their texture, shape, size etc. It influences the workability, as well as initial strength. Size of aggregates that are used effects the strength and workability of concrete. It also effects the water quantity as maximum size of aggregate reduce the surface area which consequently decrease the water demand and hence reduce the workability.

Aggregates with high strength are not suitable for concrete. This is due to their high modulus of elasticity as compared with that of the cement paste; due to this contrary stress concentrations occur which may damage the concrete in its mechanical behavior. It was also observed that for optimum compressive strength with high cement contents and low water cement ratios, the maximum size of coarse aggregate should be kept minimum at the rate of 12.5 mm or 9.5 mm. It has been suggested that ideal aggregate should be angular, clean, cubical, 100 percent crushed and continuously graded with a minimum of flat and elongated particles.

1.3.2.2 Fine Aggregates

Aggregates which go through across 4.75mm sieve are known to be fine aggregates. It has high tensile strength. It can be obtained by digging. It regulates the workability at particular water content. Fine aggregates which have fineness modulus from 2.5-3.3 are suitable for High strength concrete. They increase the workability and strength.

A disadvantage of fine aggregate concrete is the increased consumption of binder compared to other types of concrete and the associated greater shrinkage and creep.

1.3.3 Water

When water is combined with cement, it generates a thick paste, this process is called hydration. This paste fills the voids. A low w/c ratio yield stronger and durable concrete. Portable water has been used in this research.

1.3.4 Wood Ash

After the combustion of the wood, the residue powder left is known as wood ash. Like combustion of wood at home fireplace or any industrial power plant. It contains enough amount of potash so it has been traditionally used by gardeners. Approximately around 0.43 and 1.82 percent of the mass of combusted wood (dry basis) results in wood ash. The conditions of the burning of wood also affect the quantity and properties of the left off ash, hence greater temperatures will decrease ash formation. Generally, wood ash consists calcium carbonate as its main component, containing 25 or even 45 %. Less than 10 % is potash, and even less than 1 % phosphate. However, these percentages may change depending on other factors too, and as burning temperature is an important variable in determining wood ash properties.

1.3.4.1 Wood Ash as a pozzolanic material

Wood Ash is highly reactive and possess pozzolanic properties. Pozzolans are materials that contain either reactive aluminous and/or siliceous materials that by themselves, have minimal or no cementitious binding characterstic but, when we mix them with lime and water, it will set hard like cement. Pozzolans are necessary ingredients and thus act as alternative of cement hence increasing the properties like durability and strength. It does not only increase the strength properties of concrete but, it also acts as an excellent technical option as it reduces the cost and due to which we can construct low-cost and affordable buildings. Pozzolans can be used in two ways (1) with calcium hydroxide and (2) with ordinary Portland cement. When mixed with calcium hydroxide, it significantly increases the properties of lime-based mortars and concretes which will contribute vastly in the construction of buildings. And when blended with ordinary Portland cement, it considerably boosts the durability and workability of the concrete, and additionally it reduces the cost. The pozzolans that are present in wood ash majorly are dependent on the presence of silica amounts, silica crystallization phase, and the size and surface area of wood ash ash particles. The burning process and temperature variation affects the chemical composition of wood ash.

1.3.4.2 Advantages of using Wood Ash

1. Cement can be substituted with wood ash in concrete.
2. Can be used as fillers for concrete.
3. Economically cheaper as compared to commercial materials.
4. Easily available.
5. Increases the strength characteristics.
6. Reduces the weight of the structure as wood ash is light in weight.
7. Easy to carry and handle.
8. Does not harm the skin if touched with bare hands.
9. Possess pozzolanic properties.

1.4 Use of Wood Ash as a Material to partially replace Cement

At present, the ecological needs focus at reducing the use of natural raw materials in the field of building/construction materials and therefore leading to an increased interest in the usage of alternative waste materials from various activities in industries, which provides significant benefits in economic as well as environmental issues. The main aim of using pozzolanic waste materials is not only its cost effectiveness but also to enhance the characterstics of concrete (especially durability). Advancement in the technology related to concrete production can extensively reduce the usage of natural as well as energy sources which as a result reduce the burden of pollutants on our environment.

Wood has been used widely as a fuel since ancient times. Wood Ash is mainly used for various other purposes like in the field of agriculture. Wood ash which constitutes of very fine particles, pollute the environment. In India, wood ash left after burning of wood is left open which causes environmental pollution, in addition this cause plantation and health problems. Therefore, to protect the environment wood ash is used in some other industries as well.

CHAPTER 2

REVIEW OF LITERATURE

The relevant literature pertaining to the use of wood ash in concrete carried out in India and abroad has been reviewed and presented as under:

2.1 Literature surveys

Zhifu Yang (2016) presented a paper in which he replaced sand with wood ash in concrete mix design. His conclusion was that wood ash was beneficial for itsuse in roller compacted concrete, conventional slag concrete, and flowable fill. Wood ash when used as replacement of cement was giving better results than addition. When wood ash was added to normal concrete it affected the workability, unit weight, and en-trapped air content to a very less extent. It slowed down the setting of concrete generally. But, in few cases, it was also seen that the process of setting fastened. It concluded that around 60% of wood ash could be added by weight in flowable fill mix.

Mohammad Iqbal Malik (2015) presented a research paper on wood ash concrete. In his work, the financial and ecological problems were solved by partially replacing cement with saw dust ash in concrete. Saw Dust Ash was used to partially replace cement as five, ten, fifteen and twenty percent by weight, for M25 mix. Compression tests, durability tests and density tests were performed after 28 days of age. Both the results obtained from normal concrete and sawdust ash concrete were then compared to each other. The results showed that upto 10 % by weight, sawdust ash could be added to concrete for particle size range 90micron.

C. Marthong (2012) has a researched on 'The possibility of using Sawdust Ash (or wood ash) as a construction material'. In his study, the ash obtained after burning saw dust was collected. Then it was sieved using a 90 micron sieve. In construction industry 3 types of OPC i.e., 33 grade, 43 grade and 53 grade are used. In this paper, comparison is made on basis of different amounts of replacement. Effects on characterstics of concrete when OPC of different grades is partially replaced by wood ash is observed. Percentage replacement of OPC with wood ash was zero,ten,twenty,thirty and 40 percent. Experimental texts have been done on mortar cubes, concrete cubes and casted beams. The mix was designed so as to achieve a target cube strength of 30 MPa at 28 days with water- cement ratio being 0.38. The compressive strength, water absorption, shrinkage and durability of concrete were also recorded. Due to low calcium content, expansion is very little. Early strength development have been observed to be about 50%-60% of their 28 days strength. Paper has adviced that the use of saw dust ash by partial replacement of cement up to a maximum of 10% by volume in all grades of cement can be done.

S. Chowdhury et al. (August 2014) has used wood ash that was obtained from a source of uncontrolled ignition of wood. He used this collected ash for partial replacement for cement in concrete. Water to binder ratio is varied(0.4 and 0.45). The replacement percentages were 5, 10, 15, 18, 20 percent. His results obtained for compressive strength,split tensile strength and flexural strength show that the strength of concrete dreduced slowly with increment in wood ash amount but, strength was observed to increase with later ages on time.

2.2 Strengths

The concrete specimens that are cubes, cylinders, and beams are tested for three properties- compressive strength test, tensile strength test, and flexural strength test.

2.2.1 Compressive strength

Out of all the tests that are performed, most important is compression test, which gives us an idea regarding the strength property of concrete. It helps us to check if concreting is done correctly or not. Some materials rupture at the compressive strength limit while others distort irreversibly. Hence, we can assume that a some amount of deformation can considered as the limit for compressive load. Compressive strength testing is necessary for design of any structure.

Compressive strength means the capability of the concrete body to oppose fracture or compression when any uniaxial compressive load is applied. Compressive strength is the capacity to bear loads resulting to decrease in size, unlike tensile strength, which endures loads resulting to elongation. Compression of any structural element is dependent on factors like water-cement ratio, strength and quality of concrete, and quality control during production of concrete.

2.2.2 Tensile strength

As compared to compression, concrete is weak in tension. It is due to the brittle nature of the concrete and it cannot resist direct tension. Cracks get developed when tensile force is applied to the element. Therefore, it is necessary to check the tensile strength of concrete so that we can find the value of load at which the cracks will appear on the element.

The highest theoretical value for indirect tension stress that is obtained by splitting the specimen, by applying a concentrated compressive line load is termed as tensile splitting strength. Tensile strength resists being stretched, while compressive strength resists being pressed together. It is calculated as force per unit area. For this test also we use the Universal Testing Machine.

2.2.3 Flexural strength

The measure of a slab or a beam to resist collapse due to bending when loads or concentrated loads are applied is called as flexural strength of concrete. It is also called as modulus of rupture test.

To perform this test, beam with the dimension (100x100x500)mm is used. The beam is placed on the machine and a point load is applied slowly at the center of the beam until it breaks. Then the corresponding reading is taken at which the beam fails.

CHAPTER 3

SCOPE OF THE STUDY

3.1 Scope of the study

Concrete of M40 grade is to be used for experimental work. The cement is replaced (by weight) by Wood Ash with the proportions of 0%, 10%, 20% and 30% to get optimized results. The important mech properties like compressive strength, split tensile strength, and flexural strength, for various mixes are to be examined for the different proportions of wood ash. Normal specimens, i.e., without replacement of cement (control mix) are also casted. The results are compared for the normal/standard (without replacement of Wood ash) specimen and the experimented specimen (with replaced proportions of Wood ash) are compared and the results are noted for future practical applications.

3.2 Objective of the study

The main idea of this research work is to obtain concrete that has high strength by replacing cement with wood ash at different percentages. The main reason of doing this project is: -

1. To understand the outcomes on compressive strength of concrete when cement is replaced with wood ash by different percentages.

2. To note the effect on split tensile strength of concrete when cement is replaced with wood ash for different proportions.

3. To note the effect on flexural strength of concrete when cement is replaced with wood ash for different proportions.

CHAPTER 4

MATERIALS AND RESEARCH METHODOLOGY

4.1 General

The main aim is to identify various properties of materials used for testing. The important materials which are used are: Portland cement, aggregates and wood ash.

4.2 Materials

4.2.1 Portland cement

Concrete constitutes of a binder material that is known as cement. The main work of cement is to make cohesiveness at highest possible rate to make high strength .To make a design mix, all the properties of cement are to be examined, i.e., physical and chemical both. Specific gravity, fineness, and consistency of cement are checked. Hydration process is examined after curing for its strength. Three grades of cement are available generally i.e., OPC 33, 43, 53 grades. In this study OPC 43 grade cement is used for design mix. The various properties of cement are examined i.e. compressive strength after 3,7 and 28 days, specific gravity, consistency and initial as well as final setting of cement. The results are shown in Table 2.

Table 2: Properties of cement (43 grade)

S.No.	Characteristics	Experimental value	Values specifies in (IS-8112:1989)
1	Specific Gravity.	3.13	-
2	Standard Consistency.	33%	-
3	Initial Setting Time (in minutes).	47	Should be greater than 30 minutes.

4	Final Setting Time (in minutes).	252	Should not be greater than 600 minutes
5	Compressive Strength (in N/mm2)		
	3days.	27.3	23
	7days.	35.6	33
	28days.	47.4	43

Table 3: Percentage Composition of Cement

Constituent	Mass%
Calcium Oxide(CaO)	61-67
Silicon dioxide(SiO_2)	19-23
Aluminum Oxide(Al_2O_3)	2.5-6
Ferric Oxide(Fe_2O_3)	0-6
Sulfate	1.5-4.5

4.2.2 Aggregates

Aggregates are major part of the concrete and they also give an orderly firmness to the concrete. To grow the density of formed mixture, aggregates are to be used in two or more dimensions. Significant role of fine aggregates is supporting in creating uniformity, and workability, in the mixture. Fine aggregates along with cement adhesive helps to grip the coarse aggregate particles. This gives plasticity to the mixture and eliminates the possibility of segregation of cement and coarse aggregates, mostly when it is important to carry the concrete from one place to another. The aggregates deliver around 75%of the bulk of the concrete and because of this its effect is highly significant. They should therefore fulfil certain provisions if the concrete is to be workable, strong, durable and reasonable. The aggregates should be properly shaped, washed, hard, tough and properly graded.

4.2.2.1 Coarse Aggregates

The standard maximum size used is 10-20 mm. Gap graded aggregates are mostly better than those unceasingly graded, which gives a compact flow.

The aggregate used are a combination of two nearby obtainable creased stone of 20 mm and 10 mm size, in 70:30 fraction respectively. The aggregates were cleaned to eliminate dust and dirt; and then dried to the surface dry form.

Table 4: Properties of Coarse Aggregates

Characteristics	Description
Color of Aggregates	Grey
Shape of Aggregates	Angular
Maximum Size of Aggregates	20mm
Specific Gravity of 20 mm Coarse Aggregates	2.73
Specific Gravity of 10mm Coarse Aggregates	2.71

Table 5: Sieve Analysis of Coarse Aggregates(20mm)

S.No.	I.S Sieve (mm)	Weight Retained (gram)	Percentage Retained (%)	Percentage Passing (%)	Cumulative Retained
1	80	0	0	100	0
2	40	0	0	100	0
3	20	53	1.77	98.23	1.77

4	10	2938.5	97.95	0.28	99.72
5	4.75	5.5	0.18	0.10	99.90
6	Pan	3	0.10	0	-
		Total=3000			Sum=201.38
					F.M=(201.38+500)/100=7.01

Note: Weight of Coarse Aggregates Taken=3000 gram.

Table 6: Sieve Analysis of Coarse Aggregates (10mm)

S.No.	IS Sieve (mm)	Weight Retained (gram)	Percentage Retained (%)	Percentage Passing (%)	Cumulative Retained
1	100	0	0	100	0
2	80	0	0	100	0
3	40	0	0	100	0
4	20	0	0	100	0
5	10	2012	67.07	32.93	0
6	4.75	958	31.93	1	67.07
7	Pan	30	1	0	99
		Total=3000			Sum=166.07
					F.M=(166.07+500)/100=6.66

Note: Weight of Coarse Aggregates Taken=3000 gram.

4.2.2.2 Fine Aggregates

The aggregates which can move past from 4.75 mm I.S sieve, are known as fine aggregates. IS: 383-1970 has distinguished fine aggregate into 4 zones grades. The classified zones become finer as we move through grading zone I to grading zone IV. In this work, fine aggregates (stone dust) were brought from Jalandhar and which was compatible to zone II. It was coarse sand which was bright brown in colour. To remove particles greater than 4.75 mm size the sand was sieved through 4.75 mm sieve. Sieve analysis is done and fine aggregate characterstics are tested as per IS: 383-1970 and outcomes are expressed in Table 7.

Specific gravity of fine aggregates is 2.49.

Table 7: Sieve Analysis of Fine Aggregates

S.No.	IS Sieve (mm) (micron)	Weight Retained (gram)	Percentage Retained (%)	Percentage Passing (%)	Cumulative Retained
1	4.75 mm	6	0.6	99.4	0.6
2	2.36 mm	59	5.9	93.5	6.5
3	1.18 mm	220	22	71.5	28.5
4	600 micron	159	15.9	55.6	44.4
5	300 micron	316.5	31.65	23.95	76.05
6	150 micron	196.5	19.65	4.3	95.70
7	Pan	43	4.3	0	-
		Total=1000			Sum=251.57
					F.M=251.57/100=2.51

Note: Weight of Fine Aggregates Taken=1000 gram.

4.2.3 Water

Water is usually taken just enough for mingling and curing purpose for concrete. To form concrete,suitable water was used in lab. No contaminants were present in it and it was good potable quality.

4.3 Test Methods

The established methods used for testing cement, aggregates (both fine and coarse) and concrete are given below:

4.3.1 Specific Gravity

Specific gravity means the proportion of the weight of a particular volume of any material to the weight of an equivalent volume of any other material. Or it is the ratio of the masses of equivalent volumes of two substances. Specific gravity of both cement as well as wood ash is examined for further study.

4.3.2 Sieve Analysis for Coarse and Fine Aggregates (IS: 2386 (Part I) -1963)

Sieve analysis is done to differentiate particle size and fineness modulus of aggregates.

4.3.3 Slump Test

Slump test is done to evaluate concrete workability and fluidity. It can also be used to find consistency and stiffness. The consistency indicates the amount of water added. This test is highly used as it is simple and less apparatus are required. The workability of fresh concrete only is to be measured with this test.

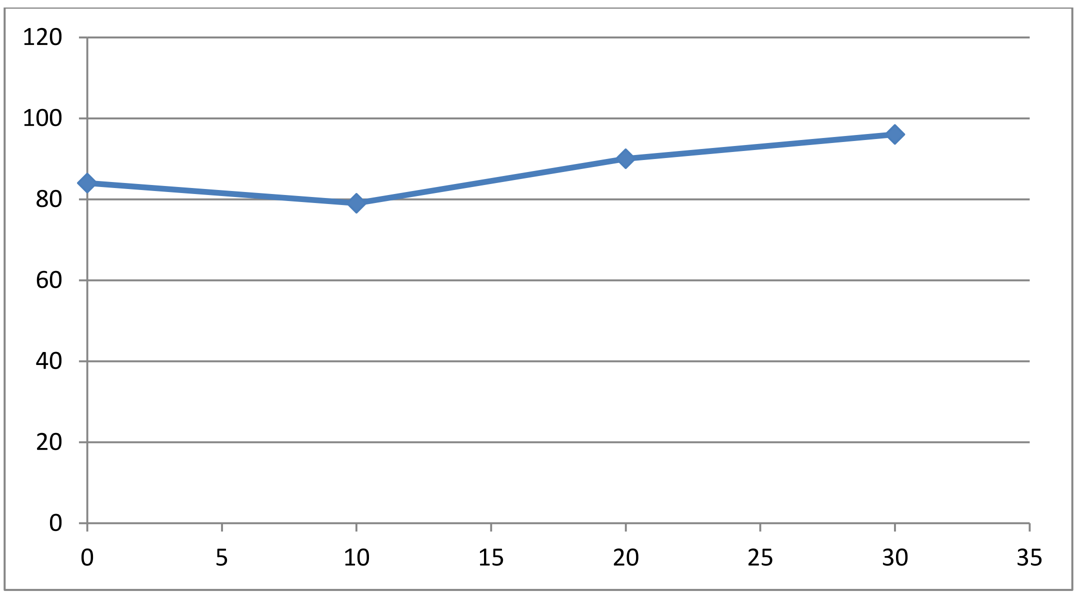
4.3.3.1 Principle of Slump Test

Slump test is done to understand the performance of the tightly packed and reversed cone of concrete under the influence of gravity. It measures the wetness or consistency of concrete. The slump cone mould that is used has a base diameter of 300 mm and 100 mm top diameter. The height of mould is 300mm.The base is placed on a regular leveled area. The concrete is then poured into the mould in 3 layers. Every layer is tampered 25 times. A 16 mm diameter long steel rod is used to do so. After the mould is fully filled with concrete the top surface is leveled by means of screening and rolling motion of tamping rod. Care must be taken that the mould doesn’t move during the pouring of concrete. After this the cone is lifted carefully in vertical direction so that unsupported concrete does not slump. The decrement in the height of the center of the slumped concrete is known as slump. Then the decrement in the height of the concrete to that of mould is noted with a scale. The results that were obtained after replacing cement with wood ash have been shown in following table:

Table 8: Slump Values after replacing Cement with Wood Ash

Percentage of Wood Ash (%)	Slump (mm)
0	85
10	78
20	87
30	94

Figure 1: Slump Values corresponding to Percentage of Wood Ash Added



4.3.4 Compressive Strength of Concrete

Sample cubes of size 150mmx150mmx150mm were removed out form the curing tank at the 7 days of age and 28 days of age and then tested with immediate effect on removal from the water (while cubes were still in the wet state). Water on the surface was cleaned, and the cube samples were tested upon. Cube was positioned at 90 degree angle to that as cast. The load is increased slowly without a sudden force till the failure of the specimen is observed and then the compressive strength was noted down. The amounts of cement, coarse aggregate(20 mm and 10 mm), fine aggregate, wood ash and water to be added for each batch i.e. for varying amount of wood ash replacement was weighed separately. Cement and wood ash were mixed dry to a steady color. Coarse aggregate was also mixed to get steady distribution through out that batch. Water was therein put into the mixture. Water was nicely mixed until a steady concrete was formed. Concrete then was poured into the cubic moulds and then filled moulds were given vibration on a vibrating table in order to compact the concrete properly. Then the casted samples were left to harden in air and left at room temperature for 24hours. The casted samples were taken out from the moulds after 24hours and were put inside a water filled tank, in the lab.

4.3.5 Split Tensile Strength of Concrete

Split tensile strength of concrete is known by forming cylinders of size 150mmx300mm. The cylinders formed are tested by placing them uniformly. Samples are removed out from curing tank at age of 7days and 28 days of wet curing and tests are done after surface water dipps down from samples. This test is performed on compression testing machine. The magnitude of tensile stress (T) that acts uniformly to the line of action of applied loading is given as:

$T=0.637P / DL$

Where, T=Split Tensile Strength in MPa

P=Load Applied.

D=Diameter of Concrete cylinder specimen(in mm).

L=Length of Concrete cylinder specimen(in mm).

The amount of cement, aggregates, wood ash and water that was required for each batch was calculated separately i.e., for different percentage of wood ash batches were weighed separately. The dry form of cement and wood ash was mixed to form a steady color separately. Fine aggregates were mixed to it in dried form. The coarse aggregates were also mixed such that a uniform distribution throughout the batch was obtained. In the start, only 50%to70% of water was added to concrete and then remaining water was put and mixed nicely to get a uniform mix. The concrete was then poured into the cylindrical moulds and filled moulds were vibrated on a vibration table to make certain that proper compaction is done. Concrete surface was fined and leveled with the trowel at the top of mould. The finished samples were left to harden in air and at room temperature for 24hours. The casted concrete samples were removed out of the moulds after 24hours and were then put in the tank full of water.

4.3.6 Flexural Testing of Concrete

The flexural strength of concrete is found out by making concrete beams of size 100mmx100mmx500mm. The beams are placed uniformly and then test is done. Casted samples were withdrawn out from water tank at age of 7and28 days of curing. Once the surface water dipped down from samples, testing was done. This test was performed on compression testing machine on beam attachment. The beams are tested for two point loading. At 1/3rd from support from both ends. Formula used for flexural strength:

fb=PL / bd2

If ‘a’ is more than 13.3cm for a 10·0cm specimen: fb =3Pa/bd2

If‘a’ is smaller than 13·3cm but greater than 11·0cm for a 10·0 cm specimen

Here;

a=the distance between line of fracture and the nearer support (measured on the centre line of the tensile side of the specimen in cm).

b=Width of the specimen(100 mm)

d=Depth of the specimen(100 mm)

L=Span of the specimen(500 mm)

The amounts of cement, coarse aggregates, fine aggregate, wood ash and water for each batch (for different replacement percentages) was weighed separately. The dry forms of cement and wood ash was mixed separately to obtain a steady color. Fine aggregate was then mixed in dry form. Coarse aggregate was mixed in such a manner that they get uniformly distributed in the concrete. Water was added to the mix and missed well. Concrete was then put in the cylindrical moulds. These moulds were given vibration on a vibrating table properly compact concrete inside the mould. The concrete at the top was levelled using a trowel. The samples were left to gain hardness in air for 24hours. The specimens were taken out of the moulds after 24hours of casting and they were put inside the water tank, filled with water in the lab.

4.4 Design Mix

Based on the IS Code IS 10262-2009, mix design of M40 grade concrete was made by partially replacement of cement with three varying percentage by weight of wood ash i.e. 10%, 20%, 30%

Grade of Concrete made= M40.

Grade of Cement used=OPC43Grade (conforming to IS-8112)

Specific gravity of cement= 3.15

Specific gravity for fine aggregates=2.62

Specific gravity for coarse aggregates=2.66

Fine aggregate taken from= Zone-II

Minimum cement amont=320 kg/m3

Maximum cement amount=450 kg/m3

Maximum water to cement ratio is 0.45

Workability= 100 mm slump

Type of Aggregate= Crushed Angular

Degree of supervision = Good

4.4.1 Target strength of mix proportioning

Formula: $f'ck = fck + 1.65s$

here,

f*ck=target average compressive strength, at 28 days. (Taken 40)

fck=characteristic compressive strength, at 28 days.

s=standard deviation. (Taken s= 5 MPa)

*Hence, target strength = 40+1.65*5 =48.25 MPa.

4.4.2 Cement Content

Minimum cement amount for severe exposure condition is 320 kg/m3.

Cement taken here is 400 kg/m3

Hence it is ok.

4.4.3 Water-Cement Ratio

Maximum water to binder/cement ratio= 0.45

Here water to binder/cement ratio taken=0.4

Water taken=0.4 x 400= 160 kg

Since 160 kg is less than 186 kg. (as per IS 10262)

Hence it is ok.

4.4.4 Volume of coarse aggregates and fine aggregates

Formula for Fine Aggregates: V=[W + (C / Sc) + (1 / P) . (Fa / Sfa)] X (1 / 1000)

Formula for Coarse Aggregates: V=[W + (C /S c) + {1 /(1-P)} . (Ca / Sca)] X (1 / 1000)

Here,

V=volume of entrapped air subtracted from volume of fresh concrete.

W=mass of water(taken as kg / m3 of concrete)

C=mass of cement(taken as kg / m3 of concrete)

Sc=Specific gravity of concrete.

P=ratio of fine aggregates to total aggregates by volume.

Fa=mass of fine aggregates(taken as kg / m3 of concrete).

Ca=mass of coarse aggregates(taken as kg / m3 of concrete).

Sfa=specific gravity(for fine aggregates).

Sca=specific gravity(for coarse aggregates).

Calculations:

As per IS 10262, for maximum size of aggregates to be 20mm; entrapped air is 2 %.

Assume that fine aggregates are 35% of total aggregates by volume.

For Fine Aggregates: 0.98 =[160 + (400 / 3.15) + (1 / 0.35) (Fa/ 2.62)](1/1000)

Fa= 635.79 kg

Therefore taking Fine Aggregates= 635 kg/m3

For Coarse Aggregates: 0.98 =[160 + (400 / 3.15) + (1 / 0.65) (Ca/ 2.66)](1/1000)

Ca= 1198.99 kg

Therefore, taking coarse aggregates = 1198 kg/m3

Since the ratio of 20mm coarse aggregates to 10mm coarse aggregates is 0.6 : 0.4

Therefore,

Cement = 400 kg/m3

Fine aggregates=635 kg/m3

Coarse aggregates (20 mm)=718.8 kg/m3

Coarse aggregates (10mm) =479.2 kg/m3

Hence;

water : cement : FA : CA(20mm) : CA(10mm) = 0.4 : 1 : 1.58 : 1.79 : 1.19

CHAPTER 5

RESULTS AND DISCUSSION

5.1 General

This unit includes the summary of observations that were achieved after performing different tests on casted samples. A research program was organised to determine the effects of wood ash on compressive strength, flexural strength and split tensile strength of concrete. It helps to assess its feasibility for use in construction. The study comprises of casting,curing and also testing of controlled and wood ash concrete specimens at different time periods.

Study includes following:

1. Performing various tests on raw materials used for making of concrete.

2. Design of mixes for wood ash concrete.

3. Casting of specimens and their curing.

4. Determination of compressive strength, flexural strength and splittensile strength of wood ash concrete.

5.2 Compressive Strength

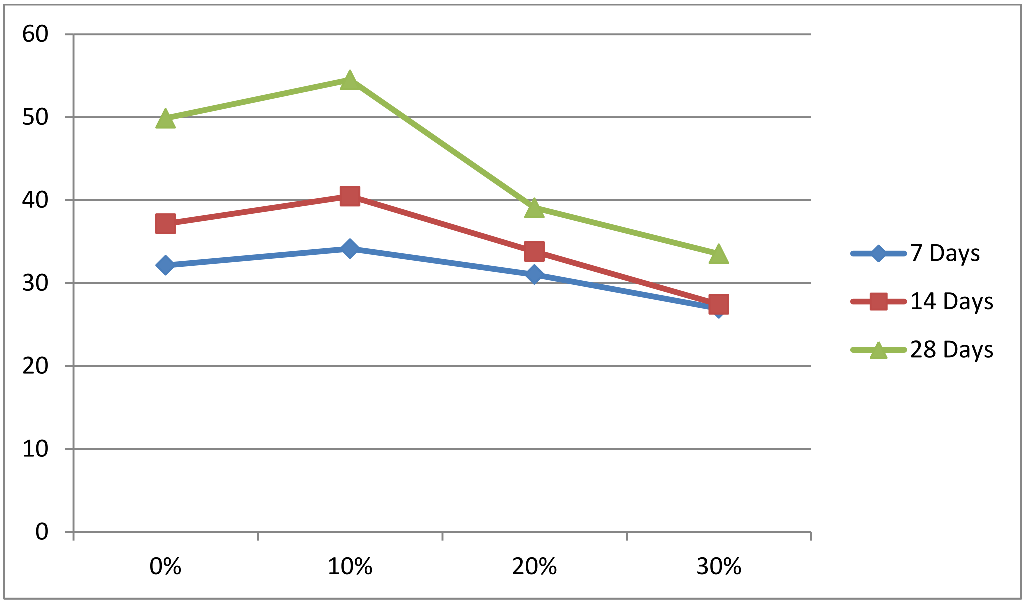
Compressive stresses in structures are mainly resisted by concrete. When compression acts on a concrete body, the member might fail, in its vertical plane (along the diagonal). Lateral tensile strains cause vertically formed cracks. When axial compression is applied, a flow in the concrete, leads to micro cracks along the vertical axis and due to the lateral tensile strains it propagates further. The 150mmx150mmx150mm cubes are casted for testing the compressive strength after 7days,14days and 28days. Specimens have also been casted for control mix and then compared with different percentages replacement of cement with wood ash i.e., for 0%,10%, 20% and 30 %. Three samples have been casted for each percentage i.e., three for 7 days, three for 14 days and three for 28 days testing.

Table 9: Compressive Strength of Cubes

Compressive Strength(MPa)								
Curing Age (Days)	0%WoodAsh		10%WoodAsh		20%WoodAsh		30%WoodAsh	
7	30.29	32.14	34.29	34.14	30.95	31.03	30.19	26.94
	33.21		33.68		30.88		26.45	
	32.94		34.47		31.26		24.19	
14	37.15	37.15	41.03	40.47	34.22	33.8	27.84	27.43
	36.97		40.12		33.90		27.21	
	37.34		40.28		33.28		27.40	
28	49.79	49.86	54.22	54.49	39.81	39.07	33.98	33.53
	50.11		54.19		39.17		34.52	
	49.68		55.07		38.23		33.11	

Figure 2: Variation in the Compressive Strength of Concrete

with the increase in the content of wood ash



The compressive strength was checked for different percentages of wood ash replacement with that of cement (by weight) i.e., for 0%, 10%, 20% and 30%. Compressive strength increases by 9.47% by 10% when cement is partially replaced with wood ash, in comparison to the normal mix after 28 days testing. When 20% replacement is done the value goes down by 20.8 % as compared to control mix after 28days testing. It further reduces for 30% wood ash replacement by 32.75%.The graph of compressive strength shows that with the increase in percentage of wood ash by replacing it with cement, the compressive strength of the concrete cubes increases. The maximum compressive strength of the cubes is found at by replacing 10 % of cement with wood ash. But on further replacing of cement with wood ash, the compressive strength of cubes start decreasing. Here, the compressive strength increases because wood ash possess some cementing properties and the reduction in the strength of the concrete is due to the pozzolanic activity and pore structure of the cementitious material. As replacing of cement with wood ash reduces clinker content of the cement the amount of cementitious material forms from pozzolanic reaction gets decreased. It is found out that strength of the concrete depends on the distribution of the void space and porosity.

5.3 Split Tensile Strength

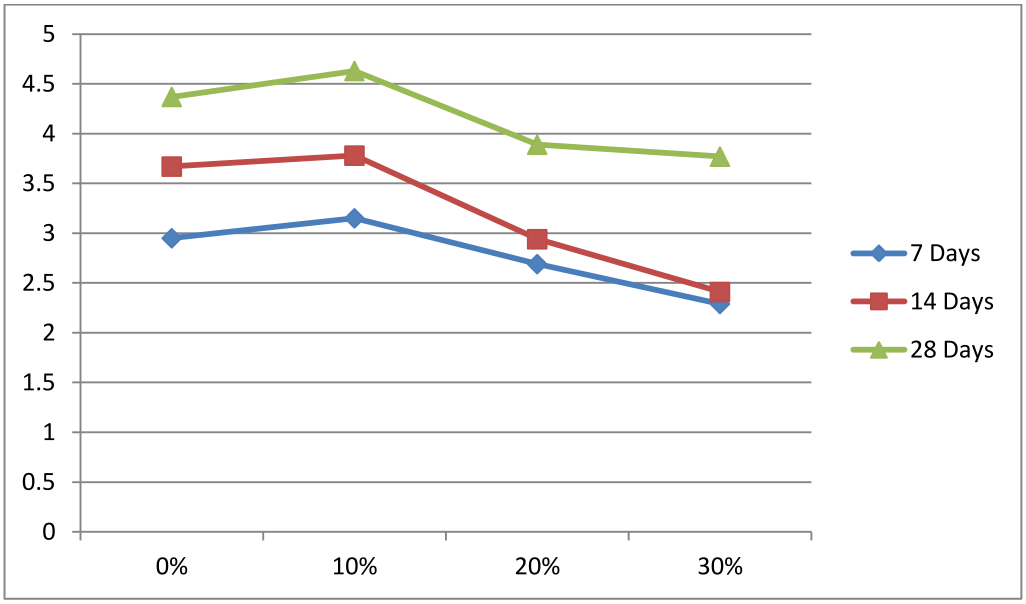
300mm x 150 mm cylinders are used for testing after 7days,14days and 28days. Specimens were also made for control mix and then they were compared with different percentages of wood ash replacement of cement. Three samples were prepared for each percentage replacement i.e., three for 7 days, three for 14 days and three for 28 days. The split tensile strength for all the mix designs were noted. The results of split tensile strength of concrete are reported in following table:

Table 10: Split Tensile Strength of Cylinder

Split tensile strength (MPa)								
Curing Age (Days)	0%WoodAsh		10%WoodAsh		20%WoodAsh		30%WoodAsh	
7	2.95	2.95	3.14	3.15	2.61	2.69	2.19	2.29
	2.97		3.21		2.76		2.34	
	2.94		3.10		2.70		2.35	
14	3.65	3.67	3.79	3.78	2.92	2.94	2.39	2.41
	3.68		3.82		2.95		2.43	
	3.69		3.75		2.96		2.41	
28	4.32	4.37	4.64	4.63	3.9	3.89	3.82	3.77
	4.39		4.62		3.88		3.66	
	4.40		4.65		3.91		3.85	

Figure 3: Variation in the Split tensile strength of concrete

with increment in the content of wood ash.



As in the case of compressive, split tensile strength was also observed to increases after 10% replacement of cement by wood ash. That is increment of 5.9 % was noted. After 20% replacement it begins to decrease by 10.9 % and then continues to decreases for 30% by 13.72% in comparison to normal mix. The highest values for split tensile strength were observed at 10% replacement which is slightly higher than control mix. After 20 % replacement, the strength decreases. Hence, for strength, 10% replacement is acceptable.

5.4 Flexural Strength

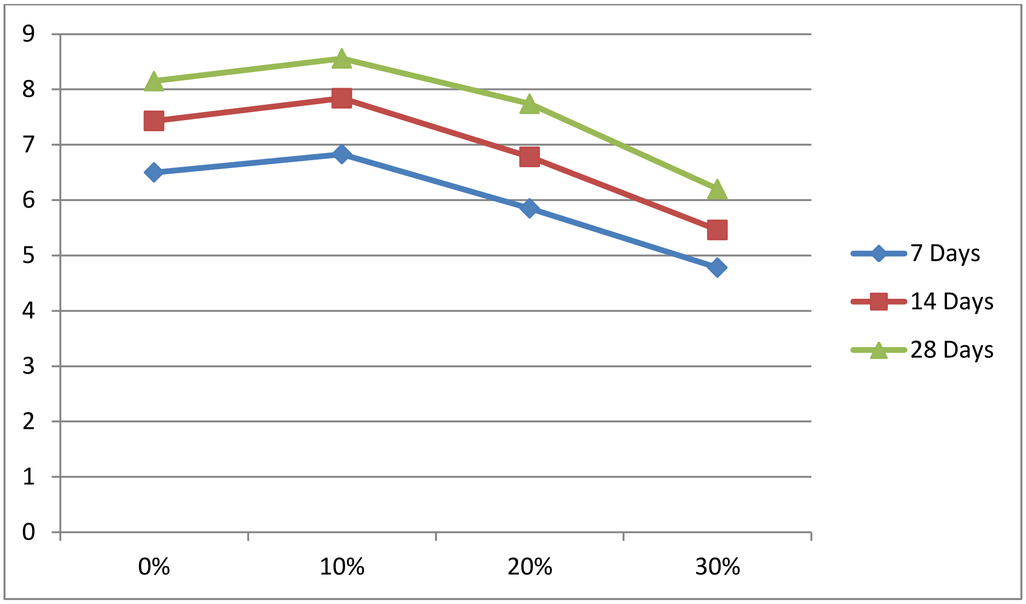
When concrete is subjected to bending, then tensile and compressive stresses as well as direct shear stresses are developed. The 100mmx100mmx550mm beams were made for testing the compressive strength after 7days,14days and 28days. Specimens were made for normal mix and then compared with different percentages of replacement of cement with wood ash i.e., for 0%, 10%, 20 % and 30 %. Three samples have been casted for each percentage i.e., three for 7 days, three for 14 days and three for 28 days testing.

Table 11: Flexural Strength of Beam

Flexural Strength (MPa)								
Curing Age (Days)	0%WoodAsh		10%WoodAsh		20%WoodAsh		30%WoodAsh	
7	6.41	6.50	6.82	6.83	5.90	5.85	4.78	4.78
	6.59		6.88		5.79		4.84	
	6.50		6.79		5.88		4.72	
14	7.42	7.43	7.79	7.84	6.72	6.78	5.44	5.46
	7.4		7.85		6.83		5.57	
	7.49		7.89		6.79		5.39	
28	8.12	8.15	8.6	8.56	7.87	7.74	6.02	6.20
	8.20		8.58		7.58		6.21	
	8.15		8.51		7.77		6.38	

For control mix after 28 days flexural strength reaches at 8.15 N/mm2 which is greater than required strength (4.5 N/mm2). For varying percentages of wood ash results are noted. When compared with control mix, flexural strength of beam increased by 5.03% for 10% replacement and then begins to decrease for 20% replacement by 4.6% . After further addition of wood ash i.e. 30% replacement, it decreased more by 23% after 28 days . The ultimate flexural strength is increased, but very slightly and only 10% replacement of cement with wood ash was beneficial.

Figure 4: Variation of Flexural Strength of Concrete with increase in Wood Ash Content



CHAPTER 6

CONCLUSION AND RECOMMENDATIONS FOR FURTHER STUDY

6.1 General

This study was done to observe the flexural, compressive and split tensile strength of concrete with varying percentages of partial replacement of cement with wood ash. Wood ash was used to replace cement at varying percentages i.e., 0%, 10%, 20% and 30%. Important tests were done after 28days of concrete curing. 18 specimens of control mix i.e., with 0% wood ash were casted. 72 specimens (with different replacement percentages) were casted to determine flexure, compressive and split tensile strength of concrete with 0.40 water-cement ratio for 4.5N/mm2 (Target Mean Flexure Strength).

6.2 Conclusion

6.2.1 Compressive Strength Analysis

The graphs representing compressive strength values obtained after testing shows that with the increase in percentage of wood ash by replacing it with cement, there is increment in the compressive strength of the casted cubes at the water- cement ratio of 0.4. The maximum compressive strength of the cubes was achieved by replacing 10% of cement with wood ash. But on increasing wood ash content, the compressive strength of cubes decreases.

The increment in compressive strength is because of the reason that wood ash possess some cementing properties. The decrease in the strength of the specimen is due to the pozzolanic activity and pore structure of the cementious material. When cement is replaced with wood ash, it reduces clinker content of the cement. The amount of cementious material that is formed by pozzolanic reaction gets decreased. It is observed that strength of concrete depends upon distribution of the void space and porosity.

6.2.2 Split Tensile Strength Analysis

The graph obtained from observed values for split tensile strength test shows that the split tensile strength of the concrete varies similarly to the compressive strength. The maximum compressive strength was noted when cement was partially replaced with wood ash at 10%; The water-cement ratio being 0.4. This increase in value is because wood ash has lower fineness modulus, so it increases the cohesiveness of the material. But on further replacing the cement by wood ash, the tensile strength decreases gradually.

6.2.3 Flexural Strength Analysis

The graph obtained from values obtained from flexural strength test of concrete shows that by replacing cement with wood ash, the flexural strength of the concrete varies in the same manner as that of compressive strength and tensile strength. The maximum flexural strength of concrete is observed when wood ash replaces cement by 10%. But on further replacement of cement with wood ash, the flexural strength decreases. This increase in flexural strength of concrete is due to cementious property of wood ash and its lower fineness modulus which provides cohesiveness property to the material.

6.3 Estimation of Materials Used

For compressive strength test 36 cubes were casted. Out of this, 9 cubes were casted for 0%, 10%, 20%,30% each. In these 9 cubes, 3 cubes for 7 days other 3 for 14 days and the rest of the three for 28 days.

Similarly 36 cubes were also casted for split tensile strength test. 9 cubes for 0%, 10%, 20%, 30% each and out of these 9 cubes , 3 cubes for 7, 14 and 28 days each.

In the same way 36 cubes were casted for flexural test, 9 cubes for 0%, 10%, 20%, 30% each and out of these 9 cubes , 3 cubes for 7, 14 and 28 days each.

Table 12: Quantity of materials required for casting cubes

Wood Ash (%)	Cement (kg)	Fine Aggregates (kg)	Coarse Aggregates-20mm (kg)	Coarse Aggregates-10mm (kg)	Wood Ash (kg)	Water (litre)
0	15.97	25.23	28.58	19	0	6.38
10	14.37	25.23	28.58	19	1.59	6.38

20	12.77	25.23	28.58	19	3.19	6.38
30	11.17	25.23	28.58	19	4.79	6.38

Table 13: Quantity of materials required for casting cylinders

Wood Ash (%)	Cement (kg)	Fine Aggregates (kg)	Coarse Aggregates-20mm (kg)	Coarse Aggregates-10mm (kg)	Wood Ash (kg)	Water (litre)
0	100.4	158.75	179.85	119.56	0	40.16
10	90.36	158.75	179.85	119.56	10.04	40.16
20	80.32	158.75	179.85	119.56	20.08	40.16
30	70.28	158.75	179.85	119.56	30.12	40.16

Table 14: Quantity of materials required for casting beams

Wood Ash (%)	Cement (kg)	Fine Aggregates (kg)	Coarse Aggregates-20mm (kg)	Coarse Aggregates-10mm (kg)	Wood Ash (kg)	Water (litre)
0	23.69	37.43	42.41	28.19	0	9.47
10	21.32	37.43	42.41	28.19	2.36	9.47
20	18.95	37.43	42.41	28.19	4.73	9.47
30	16.58	37.43	42.41	28.19	7.10	9.47

6.3.1 Cost Analysis

If we analyze the cost, then we will observe that out of every ten bags of cement used to make concrete, one bag of cement can be replaced by wood ash bag which is very cheap as compared to a bag of cement.

6.4 Recommendations

Although when wood ash is used to partially replace cement it enhances the concrete strength but this increase in the strength of concrete can be enhanced more if we add 1 % steel fibre along with 10 % replacement of cement by wood ash.

On the addition of 1 % steel fibre in the concrete mix, compressive strength, split tensile strength as well as flexural strength of the concrete may show significant increase in their strength.

This addition of steel fibre by 1 % will not show effective results, if cement is replaced by more than 10 % with wood ash. Along with that water cement ratios also needs to be kept high at around 0.4 to 0.45, it should not be less than 0.4.