EXPERIMENTAL STUDY ON E-WASTE AND JUTE FIBER INCORPORATED CONCRETE

A PROJECT REPORT

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in partial fulfillment for the award of the degree

of

BACHELOR OF ENGINEERING

IN

CIVIL ENGINEERING

PSG INSTITUTE OF TECHNOLOGY AND APPLIED RESEARCH, COIMBATORE

ANNA UNIVERSITY: CHENNAI 600 025

APRIL 2018

ANNA UNIVERSITY: CHENNAI 600 025

BONAFIDE CERTIFICATE

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INTERNAL EXAMINER

EXTERNAL EXAMINER

ABSTRACT

Recycling of Electronic waste is an emerging issue due to the rapid development of IT industry, which causes serious hazards to the human health and environment. Low recycling rate of E-waste introduced an feasible idea of using E-waste as an partial replacement for coarse aggregate. As concrete is weak in tension, has brittle character and low ductility. Use of reinforcement in concrete to increase the ductility needs skilled labour. Alternatively additional use of jute fiber to concrete in uniformly distributed manner may provide better solution. Jute fibers arrest cracks formation and propagation of cracks, thus improving the strength and ductility. An experimental study on the behaviour of partial replacement of coarse aggregate with E-waste in the range of 5%, 10%, 15%, 20%, with the constant quantity of jute as 1% of cement in M_{20} grade mix has been carried out. The mechanical properties and durability of E-waste concrete specimens was compared with the control specimen to arrive at the optimum percentage of replacement of coarse aggregate by E-waste.

ACKNOWLEDGEMENT

First of all we like to thank the Almighty, the great architect of the whole Universe for his wonderful artistic sense. We express our whole hearted indebtedness to our management for their warm blessings, moral support and constant encouragement at various stages of the course and for providing all necessary facilities for completing this project.

We express our heartfelt gratitude to our beloved Principal, **Dr.P.V.MOHANRAM, M.Tech, Ph.D,** who has always inspired us to pursue learning through research and practice.

We thank our Vice-principal, **Dr.G.CHANDRAMOHAN, M.E, Ph.D,** for his moral support.

We thank our respected Head of the Department, **Dr.M.I.ABDUL ALEEM, M.E, Ph.D,** for his scholarly suggestions, constant encouragement and assistance in completing this project.

We are highly indebted to **Mr.V.NAVIN GANESH, M.Tech,** Assistant Professor, for his guidance and constant supervision.

We thank our project coordinators **Mr.S.R.MAHESH** and **Mr.S.ELAYARAJA**, for their constant suggestions and valuable help rendered during the entire course of this project work.

We extend our love and thanks to our Parents and Friends for their constant support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATION

PPC	-	Portland pozzolona cement
RCC	-	Reinforced cement concrete
M-SAND	-	Manufactured sand
JFRCC	-	Jute Fiber Reinforced Concrete Composites
E-WASTE	-	Electronic waste
PCB	-	Printed circuit boards
CTM	-	Compression Testing Machine
C1	-	1% Jute & 5% E-Waste
C2	-	1% Jute & 10% E-Waste
C3	-	1% Jute & 15% E-Waste
C4	-	1% Jute & 20% E-Waste

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Concrete is one of the oldest and the most common construction materials in the world, mainly due to its low cost, availability, its long durability, ability to sustain extreme weather climates. Approximately one ton of concrete is used per capita per year throughout the world. On the other hand other construction material such as steel and fibers are more expensive and less common than concrete materials. Concrete is good in compression but weak in tension. High temperature induces high temperature gradients, which in turn induces high tensile stresses. Due to its low tensile strength micro cracks propagate leading to brittle failure of concrete. Thus reinforcement of concrete is required to allow it to handle tensile stresses.

1.2 M-SAND IN CONCRETE

When rock is crushed and sized in a quarry the main aim has generally been to produce coarse aggregates and road construction materials meeting certain specifications. Generally, this process has left over a proportion of excess fines of variable properties, generally finer than 5-mm size. The premixed concrete industry has for some time tried to find ways to utilize this material as a controlled replacement of natural sand. In order to do this it has been recognized that provided the material is appropriately processed and selected from suitable materials then a sand replacement can be produced to meet the highest quality concrete specification. Manufactured sand is defined as a purpose-made crushed fine aggregate produced from a suitable source material. Production generally involves crushing, screening and possibly washing. Separation into discrete fractions, recombining and blending may be necessary. It is recognized from both local and overseas experience, that some quarry sources or some rock types within any particular quarry would not be suitable for use as manufactured sand in concrete. It is clear from the definition for manufactured sand that it was never acceptable for quarries to produce a crusher dust that results from the fine screenings of all quarry crushing and call this material manufactured sand.

1.3 JUTE FIBERS

Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. It is produced primarily from plants in the genus Corchorus, which was once classified with the family Tiliaceae, and more recently with Malvaceae. The primary source of the fiber is Corchorus olitorius, but it is considered inferior to Corchorus capsularis. "Jute" is the name of the plant or fiber that is used to make burlap, hessian or gunny cloth.

1.4 JUTE FIBERS IN CONCRETE

The natural jute fiber can be the effective material to reinforce concrete strength which will not only explore a way to improve the properties of concrete, it will also explore the use of jute and restrict the utilization of polymer which is environmentally detrimental. In Bangladesh& India jute is locally available and, hence, less expensive. To achieve this goal, an experimental investigation of the compressive, flexural, and tensile strengths of Jute Fiber Reinforced Concrete Composites (JFRCC) has been conducted. Cylinders, prisms, and cubes of standard dimensions have been made to introduce jute fiber varying the mix ratio of the ingredients in concrete, water-cement ratio, and length and volume of fiber to know the effect of parameters as mentioned. Flexural, compressive, and tensile strength tests have been conducted on the prepared samples by appropriate testing apparatus according to standard specifications. The results of JFRCC were also compared to the plain concrete. The large cut length and higher content of reinforcing materials (jute fiber) result to the unfortunate tendency of balling formation and high porosity of composites followed by the degrading of mechanical properties of JFRCC in reference to plain concrete. But in the incorporation of short and low fiber content, an intact structure develops which enhances the mechanical properties of the same composite. It was also noted that all the remarkable increment values were found mostly in the presence of higher cement content. So it can be concluded that the presence of jute fiber with more cement content strengthens the concrete in greater extent.

1.5 E-WASTE IN CONCRETE

In the present scenario, no construction activity can be imagined without using concrete. Concrete is the most widely used building material in construction industry. The main reason behind its popularity is its high strength and durability. Today, the world is advancing too fast and our environment is changing progressively. Attention is being focused on the environment and safeguarding of natural resources and recycling of wastes materials. One of the new waste materials used in the concrete industry is E-waste. For solving the disposal of large amount of E-waste material, reuse of E waste in concrete industry is considered as the most feasible application. E waste is one of the fastest growing waste streams in the world. In developed countries, previously it was about 1% of total solid waste generation and currently it grows to 2% by 210. In developing countries, it ranges 0.01% to 1% of the total municipal solid waste generation. E-waste is an emerging issue posing serious pollution problems to the human and the environment options need to be considered especially on recycling concepts. E

Waste describes loosely discarded surplus, obsolete, broken, electrical or electronic devices. Rapid technology change, low initial cost has resulted in a fast growing surplus of electronic waste around the globe. Several tonnes of E-waste need to be disposed per year. E waste contains numerous types of substances and chemicals creating serious human health and problems if not handled properly.

Owing to the scarcity of coarse aggregate for the preparation of concrete, partial replacement of E-waste with coarse was attempted. The work was conducted on M20 grade mix. In this work, the percentage of various replacement levels of coarse aggregate with E-waste in the range of 0%, 5%, 10%, 15%.Finally the mechanical properties and durability of the concrete mix specimens obtained from the addition of these materials will be compared with that obtained by using control concrete mix.

CHAPTER 2

LITRERATURE REVIEW

2.1 GENERAL

Cement concrete composite is the most important building material and its consumption is increasing in all countries. The disadvantage of cement concrete is its brittleness, with relatively low tensile strength and poor resistance to crack opening. To overcome this design of a durable and low cost fibre reinforced cement concrete for building construction is followed which is a technological challenge in developing countries. The type of fibres currently been used include steel, glass, polymers, carbon and natural fibres. Natural fibres have the potential to be used as reinforcement to overcome the inherent deficiencies in cementations materials. Considerable researches are being done for use of reinforcing fibres like jute, bamboo, sisal, coconut husk in cement composites mostly in case of building materials. Use of natural fibres in a relatively brittle cement matrix has achieved considerable strength, and toughness of the composite. The durability of such fibres in a highly alkaline cement matrix must be taken into consideration by effective modifications. A specific chemical composition has to be chosen that can modify the fibre surface as well as strengthen the cement composite.

Research concerning the use of Electronic waste to augment the properties of concrete has been going on for recent years. Non recycling Waste materials are posing serious pollution problems to the human and the environment. So, new effective waste management options need to be considered. Efforts have been made in the concrete industry to use non-biodegradable components of E-waste as a partial replacement of the coarse or fine aggregates. The use of these materials in concrete comes from the environmental constraints in the safe disposal of these products. Use of E-waste materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects.

2.2 PREVIOUS RESEARCH WORK ON E-WASTE AND JUTE REINFORCED CONCRETE

In the following, a summary of the articles and papers found in the literature, about the Jute and E-waste reinforced concrete and some of the projects carried out with this type of concrete, is presented:

S. Manoj Kumar et al (2015): Study on Replacement of coarse Aggregate by E-Waste in concrete

Reported that E-waste is used as one such alternative for coarse aggregate. Owing to scarcity of coarse aggregate for the preparation of concrete, partial replacement of E-waste with coarse aggregate was attempted. The replacement of coarse aggregate with E-waste in the range of 0%,5%,10%,15% and 20 % was made. Finally the mechanical properties and durability of the concrete mix specimen obtained from the addition of these materials is compared with control concrete mix. The reuse of E-waste results in waste reduction and resources conservation.

N.Panneer selvam et al (2015): Recycle of E-waste in concrete

Studied that the use of E-waste material is a partial solution to environmental and ecological problems. In this work printed circuit board is used as E-waste material. .concrete mixes with different percentages of E-waste were casted. It has been decided to make three different types of conventional specimens with partial replacement of E-waste on a percentage of 10%,20% and 30% to coarse aggregate with water cement ratio of 0.45.for conventional specimens are also prepare for M20 concrete without using E-waste aggregates. The effects of physical and mechanical properties of the concrete were studied.

P.Krishna prasanna et al (2014): Strength variations in concrete by Using E-Waste as coarse aggregate

A study is made by preparing specimens by utilizing E-waste particles as coarse aggregates in concrete with a percentage replacement from 0%,5%,10%,15%,20%.And conventional specimens are also prepared for M30 grade concrete without using E-waste aggregates. By conducting test for both specimens the hardened properties of concrete are studied..This study ensures that reusing of E-waste as coarse aggregate substitutes in concrete gives a good approach to reduce cost of materials and solve solid waste problems posed by E-waste.

S.P. Kale et al (2013): Recycling of Demolished concrete and E-waste

Studied the compressive strength, tensile strength, flexural strength and bond strength by using fresh concrete material, waste concrete material and E-waste material. Various mixes were prepared for carrying out the research by varying the preparations of cement, sand and aggregate designed for characteristic strength of M25.The compressive strength was tested in laboratory after 7 and 28 days. The main aim of this study recommends the recycling of waste concrete and sand material in the production of new concrete.

R.lakshmi et al (2011): investigations on durability characteristics of e- plastic waste incorporated concrete

Reported that the use of E-waste materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in landfill cost, saving in energy, and protecting the environment from possible pollution effects. Compressive strength, Tensile strength and Flexural strength of concrete with and without E-waste as aggregates was observed which exhibits a good strength gain .However strength noticeably decreased when the e plastic content was more than 20%. He has concluded that 20% of E-waste aggregate can be incorporated as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties.

Sai vijaya krishna et al: A comparative study of jute fibre reinforced concrete with plain cement concrete

Studied the behaviour of jute fibres mixed in concrete as a reinforcing material for improving the mechanical properties of concrete. Several experiments were conducted on jute fibres, jute-cement mortar and jute fibre reinforced concrete in this research. For this study, a total of 24 mortar specimens for compressive strengths and 144 concrete specimens i.e. 48cubes, 48 prisms and 48 cylinders each consisting of ordinary concrete, 0.5%, 1% and 2% Jute fibre reinforced concrete are tested for their compressive, flexural and split tensile strengths respectively for different curing periods such as 7, 28, 56 and 90days.It is observed that the JFRC specimens with 1% jute content, cured up to 56 days has significant improvement of mechanical properties such as compressive strength, flexural strength and split tensile strength with respect to ordinary concrete.

Vipul kumar (2015) :study of cement compositions in addition of jute fibre

Examined various engineering characteristics of Cement Composites when reinforced with jute fibre. Series of experiments such as Test for compressive strength, Test for workability and Test for Consistency with different volume fraction of jute fibre has been performed. And results Indicates Fibre Reinforced Concrete is quite feasible when it comes to low cost construction with definite strength and durability. With the increase of % of fibre-cement ratio the slump will decrease and increase the workability

(Average=55mm). Jute fibre comes out to cheap and eco-friendly natural fibre and also effective for Low-Cost housing construction.

Mohd. usman et al (2017) : Experimental study of jute fibre reinforced concrete

Analysed the effect of jute fibre reinforcement on the strength and ductility properties of concrete. Flexural and compression characteristics of the fibre reinforced concrete are measured experimentally. The results of the compression test indicated that the presence of jute fibre tends to reduce the compressive strength of concrete at higher fibre content. Despite the minimal reduction in the compressive strength at higher jute fibre content, there is an improvement of ductility after cracking of concrete. Similarly, the bending test results indicated that the modulus of rupture of concrete increases by 50% at 0.50% jute fibre content. Jute fibre significantly improves the toughness behaviour of concrete.

Mohammad Zakaria et al (2016): Scope of using jute fiber for the reinforcement of concrete material

Studied that natural jute fibre can be the effective material to reinforce concrete strength which will not only explore a way to improve the properties of concrete, it will also explore the use of jute and restrict the utilization of polymer which is environmentally detrimental. In Bangladesh, jute is locally available and less expensive. To achieve this goal, an experimental investigation of the compressive, flexural, and tensile strengths of Jute Fibre Reinforced Concrete Composites (JFRCC) has been conducted. Flexural, compressive, and tensile strength tests have been conducted on the prepared samples by appropriate testing apparatus according to standard specifications. The results of JFRCC were also compared to the plain concrete.. It was noted that all the remarkable increment values were found mostly in the presence of higher cement content. So it can be concluded that the presence of jute fibre with more cement content strengthens the concrete in greater extent.

Gopi Raval et al (2017): Effects of Jute Fibres on Fibre-Reinforced concrete

This research aims at providing environment friendly fibres to fibre reinforced concrete. Concrete is one such basic component in which constant up gradation has always been implemented in order to improve its properties by adding different admixtures or additives. Jute Fibre is one such material which could be added in concrete to improve its properties and strength without having any environmental damage.

Thus several studies and research works were carried out on E-waste and jute reinforced concrete by many people. These studies include comparison of properties with those of normal concrete, effect of inclusion of various materials in concrete and so on. With the knowledge gained from the results from previous works, some of the concepts were used in this study.

CHAPTER 3

METHODOLOGY

3.1 METHODOLOGY OF WORK

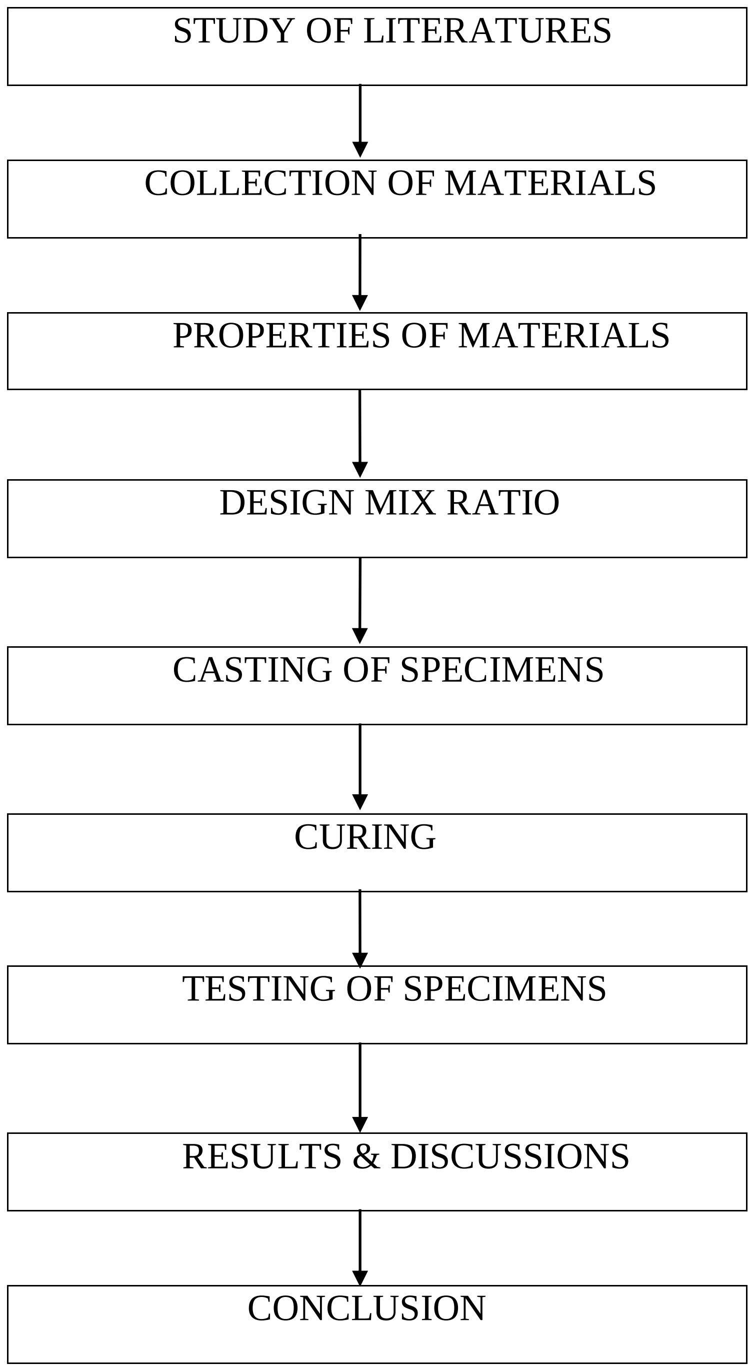

Fig 3.1 Methodology of work

3.2 STUDY OF LITERATURES

The different literatures (as listed in chapter 2) for jute reinforced concrete and the E-waste reinforced were collected. The percentage of E-waste and jute used in the concrete were studied and the results obtained from the literatures were taken into consideration.

3.3 COLLECTION OF MATERIALS

The materials collected for the experiments include

- Coarse aggregate
- Fine aggregate
- Cement
- Water
- Jute fiber
- E-waste (printed circuit boards)

3.4 PROPERTIES OF MATERIALS

The properties of material were found out by conducting the following test

- Test on coarse aggregate
- Test on fine aggregate
- Test on cement
- Test on E-waste
- Test on jute fiber
- Test on fresh concrete
- Test on hardened concrete

3.5 DESIGN MIX RATIO

1. Cement = 348.36kg/m^3
2. Water = 192 litre
3. Fine aggregate = 666.3kg/m^3
4. Coarse aggregate = 1200kg/m^3
5. Water-cement ratio = 0.55

Mix ratio = 1:1.912:3.44

The mix design for M20 grade of concrete was calculated.

3.6 CASTING OF SPECIMENS

Three types of moulds were used for casting

Cube:

- Size - 0.15 m*0.15 m*0.15 m
- Volume – 3.375 x 10^{-3} m^3
- Cylinder:
- Diameter – 0.15 m
- Height – 0.5 m
- Volume – 8.835 x 10^{-3} m^3

Beam:

- Length – 0.50 m

- Breath – 0.1 m
- Height – 0.1 m
- Volume - 5 x 10^{-3} m^3

3.7 CURING

The moulds after 24 hours were cured in water for 7 days and 28 days.

3.8 TESTING OF SPECIMENS

The following tests were conducted in the hardened concrete

- Compression strength test
- Split tensile strength test
- Flexural strength test

CHAPTER 4

EXPERIMENTAL STUDY

4.1 INTRODUCTION OF WORK

The naturally available jute fiber can be the effective material to reinforce concrete strength which will not only explore a way to improve the properties of concrete, it will also explore the use of jute and restrict the utilization of polymer which is environmentally detrimental. In Bangladesh and India, jute is locally available and, hence, less expensive. Due to the speedy development in the construction industry, the need for coarse aggregate is rapidly increasing so the exploitation of natural resources goes on demolished. So this project aims at making JFRC a cost effective material by replacing coarse aggregate partially with E-waste. It is also proposed to compare the performance of the prepared concrete with that of the conventional concrete. The basic properties such as fineness modulus, specific gravity and consistency were determined. The cubes of standard size of (150 x150 x 150) mm cylinder of (150 x 300) mm and beams of (500 x 100 x 100) mm were cast for the control specimen and for the partial replacement of coarse aggregate with E-waste and the compressive strength, split tensile strength and flexural behaviour of beams were determined.

4.2 OBJECTIVE OF WORK

The objective of the work is to develop JFRC by replacing coarse aggregate with E-waste in different proportions and thereby reducing the use of coarse aggregate. The compressive strength, split tensile strength and flexural behaviour of JFRC formed with different proportions of E-waste are compared with conventional JFRC and how does JFRC differs from conventional concrete.

4.3 MIX PROPORTIONS OF SPECIMENS

The ratio of cement, fine aggregate and coarse aggregate used in this mix is 1:1.912:3.44. The water/cement ratio was kept as 0.55.

Table 4.1 shows the different mix proportions of concrete used in this work.

Table 4.1 Different mix proportions of concrete

S.NO	SPECIMEN IDENTITY	% OF JUTE	% OF E-WASTE
1	Control mix	0	0
2	JFRC1	0.5	0
3	JFRC2	1	0
4	JFRC3	2	0
5	E- WASTE RC1	0	5
6	E- WASTE RC2	0	10
7	E- WASTE RC3	0	15
8	E- WASTE RC4	0	20

Table 4.2 shows the different mix proportions of E-waste in JFRC used in this work.

Table 4.2 Different proportions of E-waste in JFRC

S.NO	SPECIMEN IDENTITY	% OF JUTE	% OF E-WASTE
1	C1	1	5
2	C2	1	10
3	C3	1	15
4	C4	1	20

4.4 EVALUATION OF PERFORMANCE OF CONCRETE IN THE WORK

Following tests for determining the properties of the ingredients, fresh concrete and hardened concrete were performed:

- **Tests on coarse aggregate**
    - Specific gravity test.
    - Water absorption test.
    - Impact test.
    - Crushing strength.
    - Elongation and Flakiness Index.
- **Tests on fine aggregate**
    - Specific gravity test.
    - Water absorption test.
    - Bulking of sand.
    - Sieve analysis.
- **Tests on cement**
    - Specific gravity test.
    - Fineness modulus test.
    - Initial setting time
    - Final setting time
- **Tests on E-waste**
    - Specific gravity test.
    - Water absorption test.
    - Impact test.
    - Crushing Strength.

- **Tests on jute fiber**
    - Tensile strength test.
    - Percentage of Elongation.
    - Young's modulus.
- **Test on fresh concrete:**
    - Slump Flow test.
- **Tests on hardened concrete:**
    - Cube Compression test.
    - Split tensile test.
    - Flexural test.

4.5 MATERIALS USED IN THIS WORK

4.5.1 CEMENT

The cement used for the study is ordinary Portland cement (53 grade) conforming to IS 12269:1987. The cement was obtained from a fresh batch and was stored in a dry, moisture proof environment. The cement used was free from lumps.

4.5.2 COARSE AGGREGATE

Construction aggregate, or simply "aggregate", is a broad category of coarse to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. The coarse aggregate used in this study is conforming to IS383:1970.

4.5.3 FINE AGGREGATE

In the study M-Sand was used as the fine aggregate. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 3/8-inch sieve. Fine aggregate is natural sand which has been washed and sieved to remove particles larger than 5 mm. Manufactured sand (M-Sand) is a substitute of river sand for concrete construction . Manufactured sand is produced from hard granite stone by crushing.The crushed sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm. The fine aggregate used in this study is conforming to IS383:1970.

4.5.4 ELECTRONIC WASTE

Electronic waste or e-waste describes discarded electrical or electronic devices. Electronic waste is the resulting product from the IT-industry. It is an inorganic, non-combustible material.

Fig 4.1 Physical appearance of E-waste

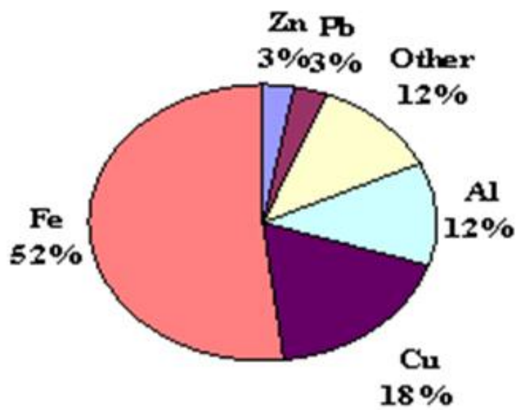

Fig 4.2 Composition of E-waste

4.5.5 JUTE FIBER

In order to improve the durability of concrete, jute fibers are used. Formation of micro cracks is reduced due to the increase in the durability of concrete. Jute fibers of 1% of weight of cement was added for specimens of JFRC. The diameter and length of the jute fibers used in the work was 0.08mm and 10cm respectively. The tensile strength of jute fiber was 230 MPa. The Specific gravity of jute fiber was 1.3 g/cc. The percentage of elongation of jute fibers is 1.7%.

Fig 4.3 Physical appearance of jute fiber

4.5.6 WATER

The potable water, as per IS 456:2007, was used for making concrete specimen. It was free from suspended matter and organic materials.

4.6 TYPES OF SPECIMENS USED IN THE STUDY

Table 4.3 shows the number of cubes, cylinders and beams cast for different mix proportions used for this work.

Table 4.3 Number of cubes, beams and cylinders casted

S.NO	SPECIMEN IDENTITY	NUMBER OF CUBES	NUMBER OF BEAMS	NUMBER OF CYLINDERS
1	Control mix	3	3	3
2	JFRC1	3	3	3
3	JFRC2	3	3	3
4	JFRC3	3	3	3
5	E-WASTE RC1	3	3	3
6	E-WASTE RC2	3	3	3
7	E-WASTE RC3	3	3	3
8	E-WASTE RC4	3	3	3
9	C1	3	3	3
10	C2	3	3	3
11	C3	3	3	3
12	C4	3	3	3

4.7 DETAILS OF EXPERIMENTAL WORKSDONE

In this project it is proposed to study the effectiveness of JFRC when coarse aggregate is partially replaced with E-waste and the strength was compared with conventional JFRC. Tests were done to investigate the physical properties of the concrete constituents and the properties of fresh and hardened concrete.

4.7.1 SPECIFIC GRAVITY OF COARSE AGGREGATE, FINE AGGREGATE AND E-WASTE

Specific gravity is defined as the ratio of the mass of a given volume of solids to the mass of an equal volume of water.

The empty weight of cylinder was taken (W_1). Then 2/3 of height of cylinder was marked. Cylinder was filled with aggregate sample up to the marked level and the weight was taken (W_2). Water was filled up to the marked level, and then weight of water along with sample was taken (W_3). Finally the weight of cylinder along with water was taken (W_4). Specific gravity was determined using the formula given below.

Specific gravity = $(W_2 – W_1) / ((W_2 – W_1) – (W_3 – W_4))$

W_1 = Empty weight of cylinder

W_2 = Weight of cylinder and aggregate

W_3 = Weight of cylinder, aggregate and water

W_4 = Weight of cylinder and water

4.7.2 SPECIFIC GRAVITY OF CEMENT

Density bottle was used to determine the specific gravity of cement. The empty weight of density bottle was taken (W_1). Density bottle was filled with cement up to 2/3 height and the weight was taken (W_2). Kerosene was filled up to the 2/3 rd height and then weight of kerosene along with cement was taken (W_3). Then the weight of density bottle along with kerosene was taken (W_4). Finally the weight of density bottle along with water was taken (W_5).Specific gravity was determined using the formula given below.

Specific gravity = $((W_2 – W_1) (W_4 – W_1)) / ((W_4 – W_1) - (W_5 – W_1))(W_5 – W_1)$

W_1 = Empty weight of density bottle

W_2 = Weight of density bottle and cement

W_3 = Weight of density bottle, cement and kerosene

W_4 = Weight of density bottle and kerosene

W_5 = Weight of density bottle and water

4.7.3 FINENESS MODULUS OF AGGREGATE

It is defined as an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves, and dividing the sum by 100. The sieve sizes are 150μ, 300μ, 600μ, 1.18 mm, 2.36 mm, 4.75 mm, 10 mm, 12.5 mm, 20 mm, 40 mm and 80 mm. The set of sieves were arranged in order and shaken well. The weight retained on each set of sieves was noted. Then the fineness modulus is determined by the formula given below.

Fineness modulus = F / 100

F = cumulative percentage of weight retained on each of a specified series of sieves.

4.7.4 CONSISTENCY TEST

The standard consistency of a cement paste is defined as that consistency which will permit a vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 33 to 35 mm from the top of the mould. 400 grams of cement was taken and it was made into paste by adding water (24% by weight of cement). The paste was prepared in a standard manner and filled into the vicat mould within 3 to 5 minutes. A standard plunger, 10 mm diameter, 50 mm long was attached and brought down to touch the surface of the paste in the test block and quickly released allowing it to sink into the paste by its own weight. The reading was taken by noting the depth of penetration of plunger. Then the second trial (26 % of water) was added and the depth of penetration of plunger was noted. Similarly, trials were conducted with higher and higher water/cement ratios till the plunger penetrates for a depth of 33 to 35 from the top. That particular percentage of water which allows the plunger to penetrate only to a depth of 33 to 35 mm from top is known as percentage of water required to produce a cement paste of standard consistency. This percentage is usually denoted as ‘P’.

4.7.4.1 INITIAL SETTING TIME

The time elapsed between the moments that the water is added to the cement to the time that the paste starts losing its plasticity.

The Vicat Apparatus is used for setting time test also. 400 grams of cement was taken and 0.85 times the water required to produce cement paste of standard consistency (0.85P) was added to the cement to make it as a paste. The paste was filled into Vicat mould within 3 to 5 minutes. The stop watch was started at the moment of water was added to the cement. The needle of size 1 mm square as shown in the figure was lowered gently and brings it in contact with the surface of the test block and quickly released. Then the needle is allowed to penetrate into the test block. At the starting of the test the needle was completely penetrated to the test block. After some time the paste started losing its plasticity and the needle penetrated only to a depth of 33 to 35 mm from top. The period elapsing between the time when water is added to the cement and the time at which the needle penetrates the test block to a depth of 33 to 35 mm from top is taken as initial setting time.

4.7.4.2 FINAL SETTING TIME

The time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure.

The needle was replaced by a circular attachment as shown in the figure. The attachment was lowered gently to bring it in contact with the surface of test block. The cement was considered as finally set, when the centre needle makes an impression and the circular cutting edge of the attachment fails to do so. In other words the paste attained such hardness that the centre needle does not pierce through the paste more than 0.5 mm.

4.8 SLUMP FLOW TEST

The slump flow is used to access the horizontal free flow of concrete in the absence of obstructions. The test method is based on the test method for determining the slump. The diameter of concrete is a measure for the filling ability of concrete. It is the most commonly used test, and gives a good assessment of filling ability. It gives no indication of the ability of the concrete to pass between reinforcement without blocking, but may give some indication of resistance to segregation.

The mould was in the shape of truncated cone with internal dimensions 200 mm diameter at the base, 100 mm diameter at the top and a height of 300 mm. The concrete needed to perform the test was taken. The base plate and the inside of slump cone were moistened. Then the concrete was completely filled in the mould and then the mould was removed. The height of slump formed is then measured.

Fig 4.4 Slump flow test

4.9 COMPRESSION TEST

Compression strength is the most common test conducted on hardened concrete, partly because it is an easy to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The cube specimens of the size 150mm x 150mm x 150mm were casted. The cube specimens were put into water curing for 28 days. After that the specimens were allowed to cool for next 24hours.Then the specimen was placed between the jaws of compression testing machine. The handle of the machine was turned clockwise to ensure locking of the specimen between the jaws. Compressive load was given till the failure of the specimen. The failure was indicated when the proving ring dial gauge begins to recede after reached the maximum load which the cube specimen can take. The compressive stress is given by the following formula. Figure shows the testing of cube specimen in CTM.

$F_c = P_c / (a \times a)$

F_c = cube compressive strength

P_c = compressive load at failure.

Fig 4.5 Testing of cubes in CTM

4.10 SPLIT TENSILE TEST

Split tensile strength test was conducted in a 2000 KN capacity of the compression testing machine by placing the cylindrical specimen of size 150 mm diameter and 300 mm height, so that its axis was horizontal to the platens of the testing machine. Narrow strips of the packing material i.e., plywood was placed between the plates and the cylinder, to receive uniform compressive stress. The load was applied uniformly at a constant rate until failure by splitting along the vertical diameter took place. The failure load was recorded and the splitting tensile strength stress was computed using the formula.

Fig 4.6 Testing of cylinder in compression testing machine.

$F_t = 2P/ \pi DL$

P = Compressive load on the cylinder in 'KN'

L = Length of the cylinder in 'mm'

D = Diameter of the cylinder in 'mm'

4.11 FLEXURE TEST

To study the flexural behaviour, the concrete beams of size 500mm x 100mm x100mm were casted. The beams were simply supported and subjected to two point loading. A hydraulic jack of 75T capacity was used to apply the load. The dial gauges were fixed at the centre of the beam and under the load points to record the deflection of the beam during test. The deflection of the beams at mid span and under the load points were measured at every 0.2T intervals of loading. At every loading stage, cracks appearing on the surfaces were marked. The beam was loaded up to failure.

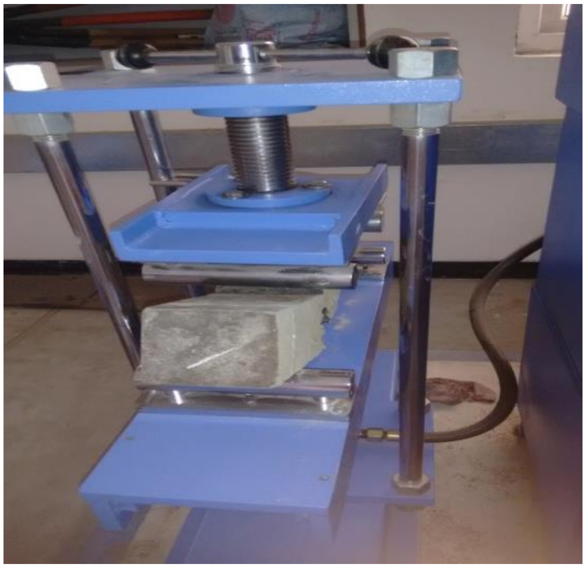

Fig 4.7 Testing of beams in flexural testing machine

The flexure strength was computed using the formula

$f_b = pl/bd^2$ (when a > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen)

or

$f_b = 3pa/bd^2$ (when a < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen

b = width of specimen (cm)

d = failure point depth (cm)

l = supported length (cm)

p = max. Load (kg)

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 RESULTS

Tests were conducted to determine the physical properties of materials used in concrete and the properties of fresh and hardened concrete. The results obtained from these tests are discussed in this chapter.

5.2 NORMAL CONSISTENCY TEST FOR CEMENT

The aim of consistency test is to find out the water content required to produce cement paste of standard consistency as specified by IS: 4031 (Part 4)-1988.

The Vicat plunger has penetrated to a depth of 33mm from the top when the % of weight of water added is 34.5%. Therefore it is the optimum amount of water needed to produce cement paste of standard consistency.

5.2.1 SETTING TIME TEST RESULT

For finding out the initial and final setting time values of the various proportions of cement the amount of water needed is 0.85 times the percentage of water required for producing paste of standard consistency.

Table 5.1 Initial and final setting time results

S.No	Initial setting time (min)	Final setting time (min)
1	30	600

Initial setting time should not be less than 30 minutes and the final setting time should not be more than 10hours as specified by IS: 4031 (Part 5)-1988.

5.2.2 SPECIFIC GRAVITY TEST RESULTS

Table 5.2 Specific gravity results

Particulars	Specific gravity
Cement	3.15
E-waste	1.90
Fine aggregate	2.58
Coarse aggregate	2.70

5.2.3 FINENESS MODULUS TEST RESULTS

Table 5.3 Fineness modulus result

Particulars	Fineness modulus
Fine aggregate	2.74

5.2.4 SLUMP FLOW TEST RESULTS

Table 5.4 Slump flow results

Proportions	Slump flow value (mm)
CONTROL MIX	80
JFRC (0.5%)	75
JFRC (1%)	74
JFRC (2%)	75
E-WASTE RC (5%)	73
E-WASTE RC (10%)	72
E-WASTE RC (15%)	72
E-WASTE RC (20%)	72
C1	69

C2	70
C3	70
C4	71

5.2.5 WATER ABSORPTION TEST RESULTS

Table 5.5 Water absorption results

Proportions	Water absorption %
E-waste	0.20
Fine aggregate	4.40
Coarse aggregate	0.24

5.2.6 COARSE AGGREGATE TEST RESULTS

Table 5.6 coarse aggregate test results

Test	Value (%)
Crushing test	21.21
Impact test	9.72
Flakiness index	38.56
Elongation index	61.40

5.2.7 FINE AGGREGATE TEST RESULTS

Table 5.7 Fine aggregate test result

Test	Value (%)
Bulking of sand	23%

5.3 TEST RESULTS ON CONVENTIONAL CONCRETE

5.3.1 COMPRESSION TEST

The test results obtained during compressive strength test for 7 days and 28days control mix are tabulated in the table 5.8

Area = 22.5 x 10^3 mm^2

Table 5.8 Compressive strength test results of control mix

SPECIMEN	LOAD (kN)		COMPRESSIVE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	466.42	626.40	20.73	27.84	20.73	27.83
2	468.42	624.40	20.81	27.75		
3	464.42	628.38	20.64	27.92		

5.3.2 SPLIT TENSILE TEST

The test results obtained during split tensile strength test for 7 days and 28days control mix are tabulated in the table 5.9

Area = 141.371 x 10^3 mm^2

Table 5.9 Split tensile strength test results of control mix

SPECIMEN	LOAD (kN)		SPLIT TENSILE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	139.95	236.09	1.98	3.34	1.98	3.34
2	141.37	236.97	2.00	3.35		
3	138.54	235.38	1.96	3.33		

5.3.3 FLEXURAL TEST

The test results obtained during flexural strength test for 7 days and 28days control mix concrete are tabulated in the table 5.10

Table 5.10 Flexural strength test results of control mix

SPECIMEN	LOAD (N)		FLEXURAL STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	16.00	22.00	3.20	4.40	3.22	4.40
2	15.85	21.05	3.17	4.30		
3	16.32	22.50	3.26	4.50		

5.4 TEST RESULTS ON JUTE REINFORCED CONCRETE

5.4.1 COMPRESSION TEST

The test results obtained during compressive strength test for 7 days and 28days jute fibre reinforced concrete of 0.5% jute are tabulated in the table 5.11

Area = 22.5 x 10^3 mm^2

Table 5.11 Compressive strength test results of 0.5% jute reinforced concrete

SPECIMEN	LOAD (kN)		COMPRESSIVE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	383.85	594.90	17.06	26.44	17.06	26.44
2	383.17	569.92	17.03	25.32		
3	384.52	616.15	17.09	27.42		

The test results obtained during compressive strength test for 7 days and 28days jute fibre reinforced concrete of 1% jute are tabulated in the table 5.12

Area = 22.5 x 10^3 mm^2

Table 5.12 Compressive strength test results of 1% jute reinforced concrete

SPECIMEN	LOAD (kN)		COMPRESSIVE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	317.25	569.25	14.10	25.32	14.10	25.66
2	312.72	577.35	13.90	25.66		
3	321.75	585.00	14.30	26.00		

The test results obtained during compressive strength test for 7 days and 28days jute fibre reinforced concrete of 2% jute are tabulated in the table 5.13

Area = 22.5 x 10^3 mm^2

Table 5.13 Compressive strength test results of 2% jute reinforced concrete

SPECIMEN	LOAD (kN)		COMPRESSIVE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	310.50	537.30	13.80	23.88	13.60	24.88
2	306.00	559.80	13.60	24.88		
3	301.50	576.67	13.40	25.63		

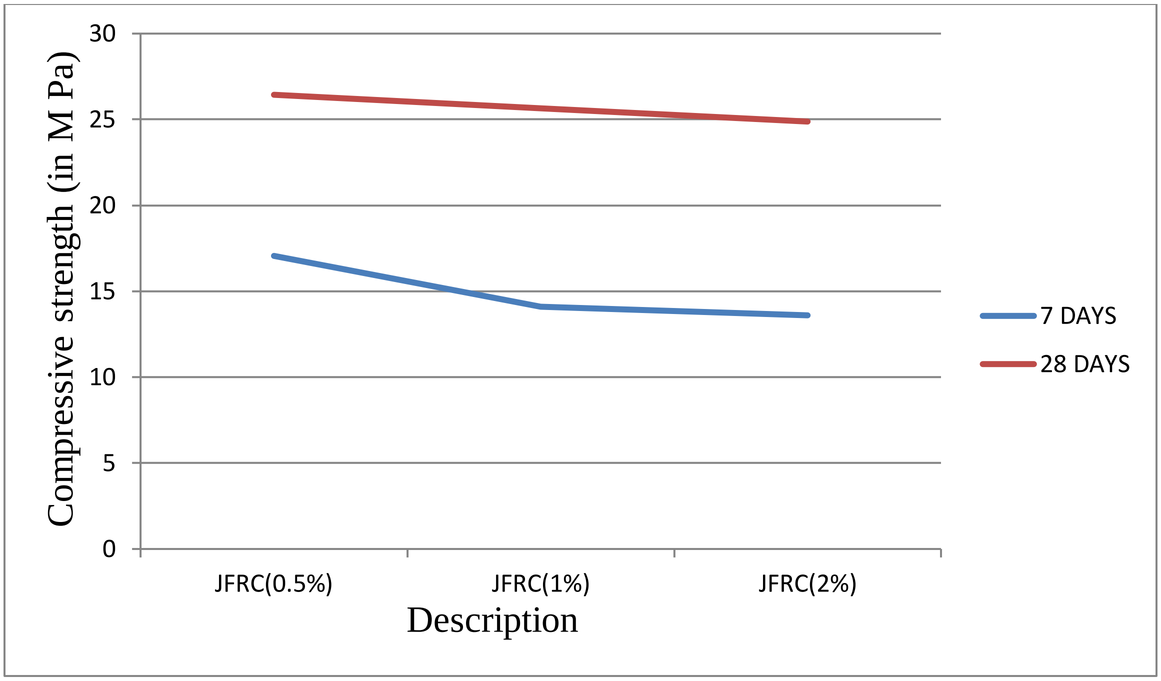

Fig 5.1 Comparison of compressive strength of different proportions of jute fibre reinforced concrete

5.4.2 SPLIT TENSILE TEST

The test results obtained during split tensile strength test for 7 days and 28days jute fibre reinforced concrete of 0.5% jute are tabulated in the table 5.14

Area = 141.371 x 10^3 mm^2

Table 5.14 Split tensile strength test results of 0.5% jute reinforced concrete

SPECIMEN	LOAD (KN)		SPLIT TENSILE STRENGTH (in M PA)		AVERAGE STRENGTH (in M PA)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	319.49	486.32	2.26	3.44	2.26	3.42
2	315.25	483.48	2.23	3.42		
3	323.73	489.14	2.29	3.46		

The test results obtained during split tensile strength test for 7 days and 28days jute fibre reinforced concrete of 1% jute are tabulated in the table 5.15

Area = 141.371 x 10^3 mm^2

Table 5.15 Split tensile strength test results of 1% jute reinforced concrete

SPECIMEN	LOAD (kN)		SPLIT TENSILE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	337.87	501.86	2.39	3.55	2.39	3.55
2	342.12	500.45	2.42	3.54		
3	333.63	503.28	2.36	3.56		

The test results obtained during split tensile strength test for 7 days and 28days jute fibre reinforced concrete of 2% jute are tabulated in the table 5.16

Area = 141.371 x 10^3 mm^2

Table 5.16 Split tensile strength test results of 2% jute reinforced concrete

SPECIMEN	LOAD (kN)		SPLIT TENSILE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	288.39	473.59	2.04	3.35	2.08	3.25
2	294.05	459.45	2.08	3.25		
3	299.75	445.31	2.12	3.15		

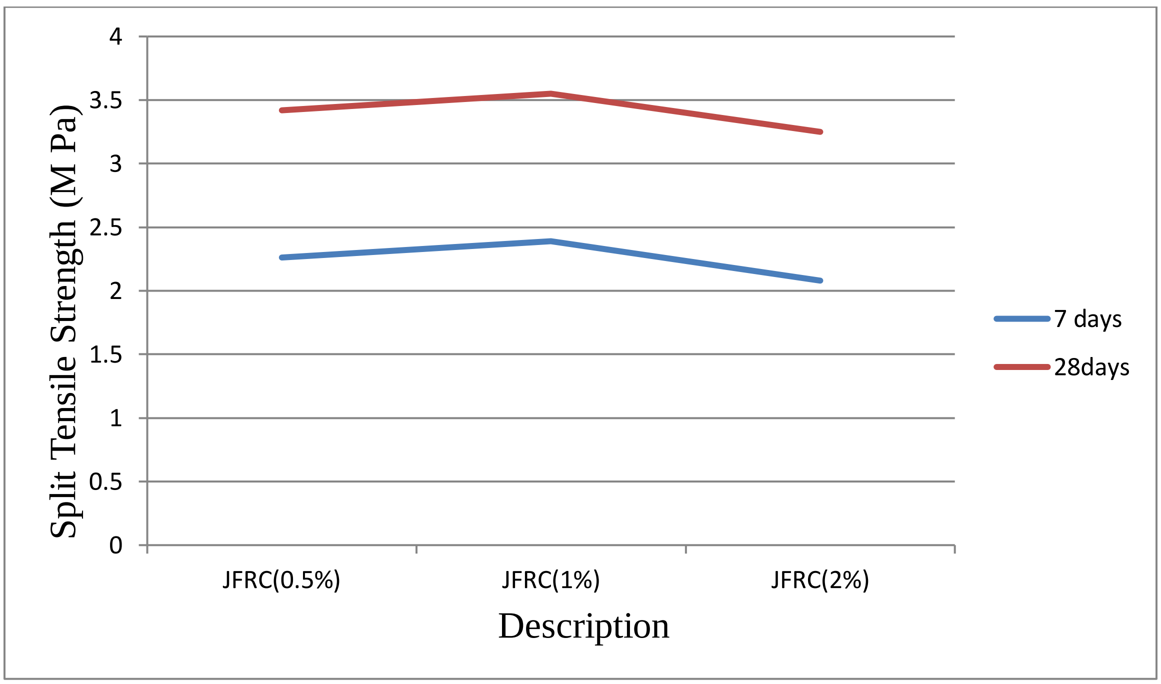

Fig 5.2 Comparison of split tensile strength of different proportions of jute fibre reinforced concrete

5.4.3 FLEXURE TEST

The test results obtained during split tensile strength test for 7 days and 28days jute fibre reinforced concrete of 0.5% jute are tabulated in the table 5.17

Table 5.17 Flexural strength test results of 0.5% jute reinforced concrete

SPECIMEN	LOAD (kN)		FLEXURAL STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	17.00	23.02	3.40	4.60	3.40	4.60
2	16.75	22.58	3.35	4.50		
3	17.20	23.55	3.45	4.70		

The test results obtained during split tensile strength test for 7 days and 28days jute fibre reinforced concrete of 1% jute are tabulated in the table 5.18

Table 5.18 Flexural strength test results of 1% jute reinforced concrete

SPECIMEN	LOAD (kN)		FLEXURAL STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	18.05	24.04	3.60	4.80	3.60	4.80
2	18.71	24.20	3.75	4.85		
3	17.25	23.75	3.45	4.75		

The test results obtained during split tensile strength test for 7 days and 28days jute fibre reinforced concrete of 2% jute are tabulated in the table 5.19

Area = 50 x 10^3 mm^2

Table 5.19 Flexural strength test results of 2% jute reinforced concrete

SPECIMEN	LOAD (kN)		FLEXURAL STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	16.00	20.54	3.20	4.00	3.20	4.00
2	16.54	19.05	3.30	3.85		
3	15.59	20.65	3.10	4.15		

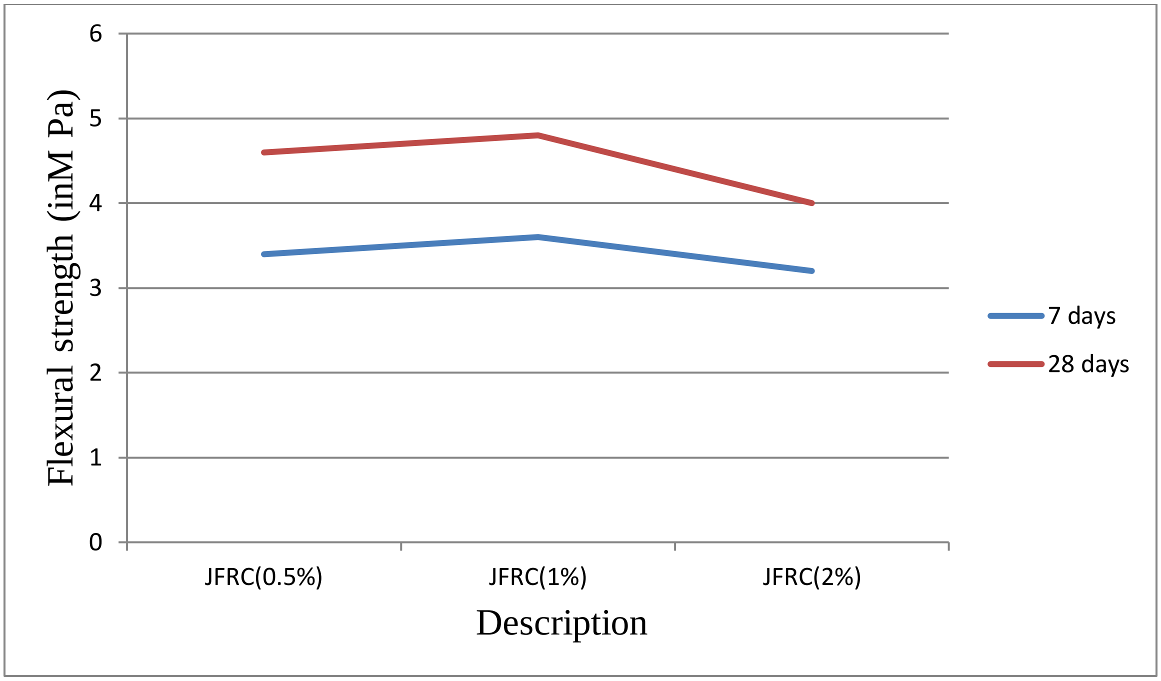

Fig 5.3 Comparison of flexural strength of different proportions of jute fibre reinforced concrete

5.5 TEST RESULTS ON E-WASTE REINFORCED CONCRETE

5.5.1 COMPRESSION TEST

The test results obtained during compressive strength test for 7 days and 28days

E –waste reinforced concrete of 5% e-waste are tabulated in the table 5.20

Area = 22.5 x 10^3 mm^2

Table 5.20 Compressive strength test results of 5% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		COMPRESSIVE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	468.57	708.75	20.80	31.60	20.80	31.60
2	463.15	706.65	20.60	31.40		
3	472.53	715.55	21.00	31.80		

The test results obtained during compressive strength test for 7 days and 28days E-waste reinforced concrete of 10% e-waste are tabulated in the table 5.21

Area = 22.5 x 10^3 mm^2

Table 5.21 Compressive strength test results of 10% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		COMPRESSIVE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	488.74	745.87	21.72	33.15	21.67	33.20
2	487.57	747.21	21.67	33.20		
3	486.45	748.12	21.62	33.25		

The test results obtained during compressive strength test for 7 days and 28days E-waste reinforced concrete of 15% e-waste are tabulated in the table 5.22

Area = 22.5×10^3 mm^2

Table 5.22 Compressive strength test results of 15% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		COMPRESSIVE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	537.07	798.75	23.87	35.50	23.87	35.50
2	533.70	803.25	23.72	35.70		
3	538.42	794.25	23.93	35.30		

The test results obtained during compressive strength test for 7 days and 28days

E-waste reinforced concrete of 20% e-waste are tabulated in the table 5.23

Area = 22.5×10^3 mm^2

Table 5.23 Compressive strength test results of 20% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		COMPRESSIVE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	390.37	562.45	17.35	25.00	17.35	25.00
2	391.95	585.78	17.42	26.00		
3	388.57	540.54	17.27	24.00		

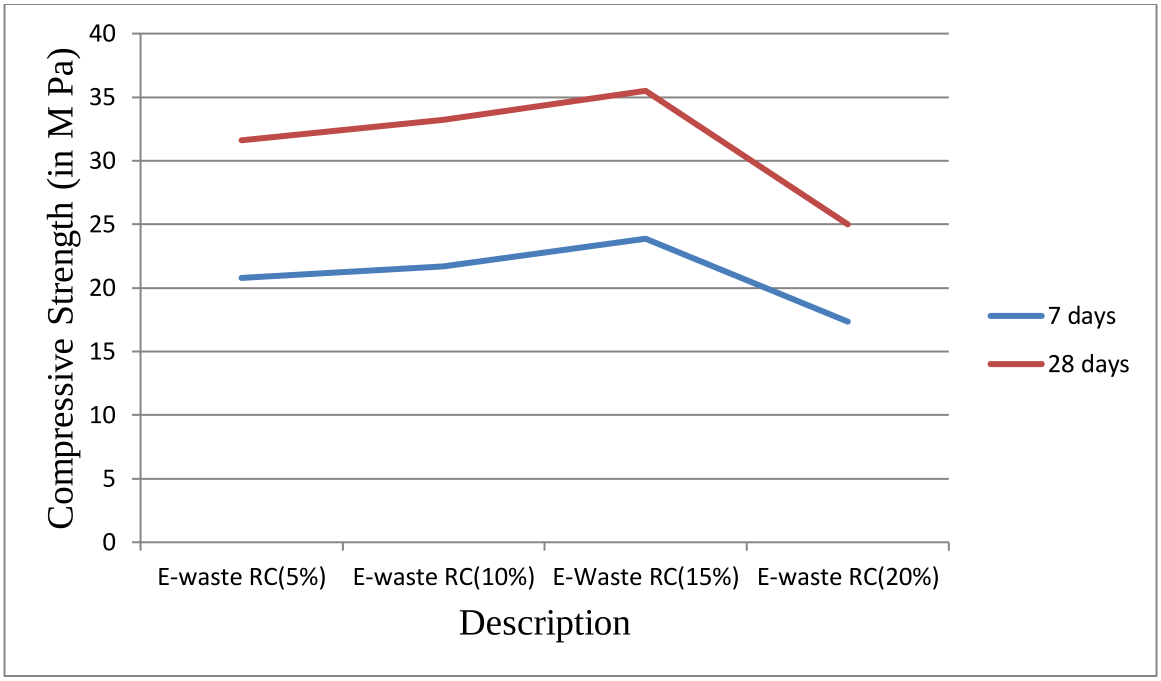

Fig 5.4 Comparison of compressive strength of different proportions of E-waste reinforced concrete

5.5.2 SPLIT TENSILE TEST

The test results obtained during split tensile strength test for 7 days and 28days

E-waste reinforced concrete of 5% e-waste are tabulated in the table 5.24

Area = 141.371 x 10^3 mm^2

Table 5.24 Split tensile strength test results of 5% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		SPLIT TENSILE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	187.32	256.58	2.65	3.63	2.55	3.63
2	180.25	260.12	2.55	3.68		
3	173.17	253.05	2.45	3.58		

The test results obtained during split tensile strength test for 7 days and 28days

E-waste reinforced concrete of 10% e-waste are tabulated in the table 5.25

Area = 141.371 x 10^3 mm^2

Table 5.25 Split tensile strength test results of 10% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		SPLIT TENSILE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	219.12	279.20	3.10	3.95	3.10	3.95
2	208.52	272.14	2.95	3.85		
3	229.75	286.27	3.25	4.05		

The test results obtained during split tensile strength test for 7 days and 28days

E-waste reinforced concrete of 15% e-waste are tabulated in the table 5.26

Area = 141.371 x 10^3 mm^2

Table 5.26 Split tensile strength test results of 15% E-waste reinforced concrete

SPECIMEN	LOAD (KN)		SPLIT TENSILE STRENGTH (in M PA)		AVERAGE STRENGTH (in M PA)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	201.45	269.21	2.85	3.81	2.85	3.81
2	208.52	272.80	2.95	3.86		
3	194.38	265.77	2.75	3.76		

The test results obtained during split tensile strength test for 7 days and 28days E-waste reinforced concrete of 20 % e-waste are tabulated in the table 5.27

Area = 141.371 x 10^3 mm^2

Table 5.27 Split tensile strength test results of 20% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		SPLIT TENSILE STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	180.95	210.64	2.50	2.98	2.65	2.98
2	187.32	214.17	2.65	3.03		
3	197.92	207.12	2.80	2.93		

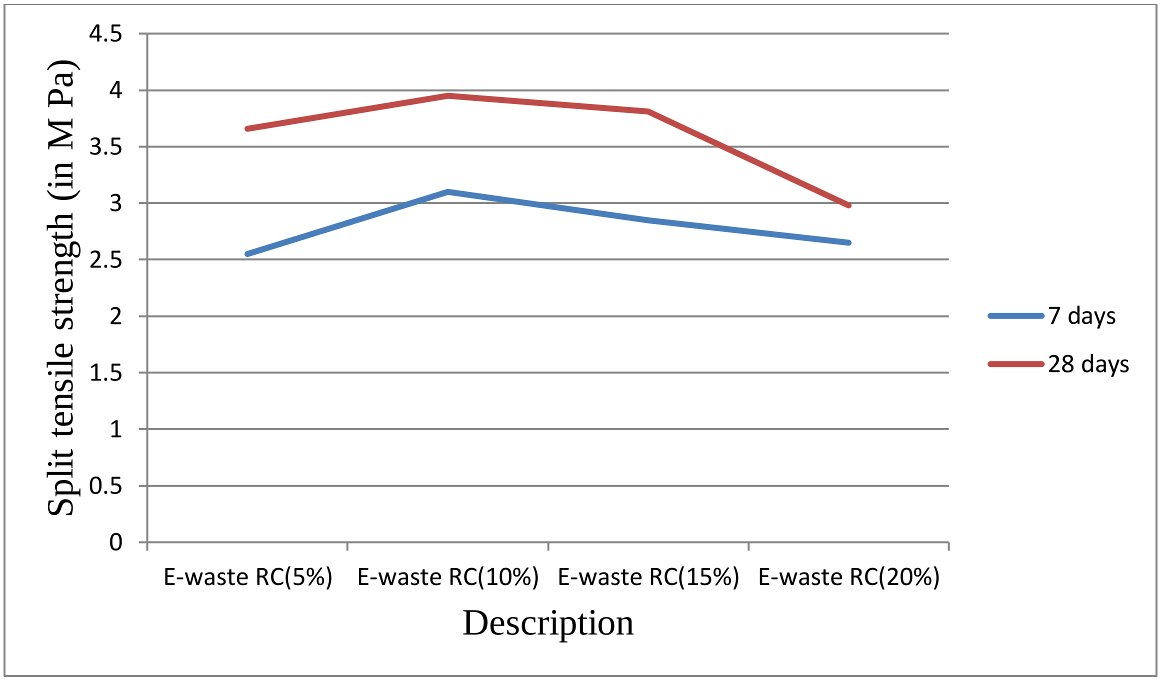

Fig 5.5 Comparison of split tensile strength of different proportions of E-waste reinforced concrete

5.5.3 FLEXURE TEST

The test results obtained during flexural strength test for 7 days and 28days E-waste reinforced concrete of 5% E-waste are tabulated in the table 5.28

Table 5.28 Flexural strength test results of 5% e-waste reinforced concrete

SPECIMEN	LOAD (kN)		FLEXURAL STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	24.25	25.55	4.90	5.05	4.90	5.07
2	24.56	25.35	4.85	5.09		
3	24.57	25.86	4.95	5.07		

The test results obtained during flexural strength test for 7 days and 28days

E-waste reinforced concrete of 10% E-waste are tabulated in the table 5.29

Table 5.29 Flexural strength test results of 10% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		FLEXURAL STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	26.56	30.25	5.23	6.00	5.23	6.00
2	26.35	32.25	5.20	6.40		
3	26.32	28.26	5.26	5.60		

The test results obtained during Flexural strength test for 7 days and 28days jute fibre reinforced concrete of 15% E-waste are tabulated in the table 5.30

Table 5.30 Flexural strength test results of 15% e-waste reinforced concrete

SPECIMEN	LOAD (kN)		FLEXURAL STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	28.55	31.57	5.65	6.34	5.65	6.38
2	28.55	32.98	5.75	6.42		
3	29.56	31.74	5.85	6.38		

The test results obtained during Flexural strength test for 7 days and 28days

E-waste reinforced concrete of 20% E-waste are tabulated in the table 5.31

Table 5.31 Flexural strength test results of 20% E-waste reinforced concrete

SPECIMEN	LOAD (kN)		FLEXURAL STRENGTH (in M Pa)		AVERAGE STRENGTH (in M Pa)	
	7 DAYS	28 DAYS	7 DAYS	28 DAYS	7 DAYS	28 DAYS
1	20.47	25.52	4.04	5.07	4.04	5.09
2	21.97	25.15	4.32	5.09		
3	18.58	25.95	3.76	5.11		

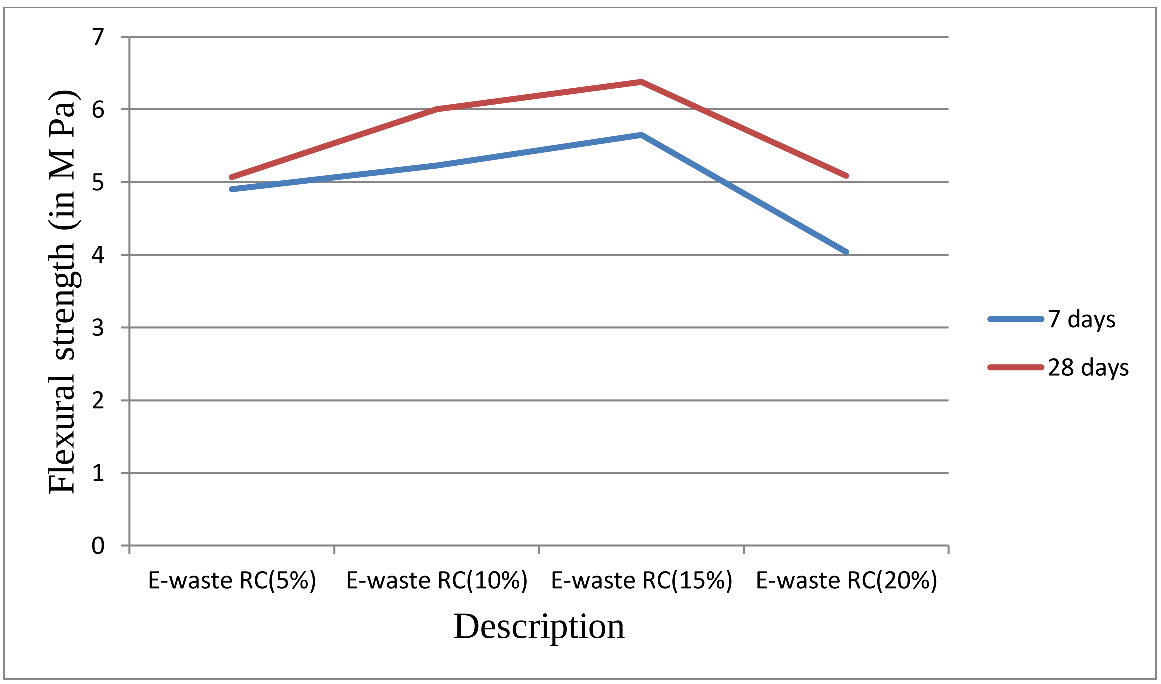

Fig 5.6 Comparison of flexural strength of different proportions of E-waste reinforced concrete

5.6 COMPARISON OF RESULTS

From the results, we have chosen 1% jute as the nominal jute percentage to be replaced with cement and15% of E-waste as the nominal replacement percentage for coarse aggregate

5.6.1 COMPARISON OF COMPRESSIVE STRENGTH

The test results obtained during compressive strength test for 7 days and 28days of jute fibre and e-waste reinforced concrete of 1% jute and 15% e-waste are tabulated in the table 5.32

Table 5.32 Compressive strength test results of 1% jute and 15% E-waste reinforced concrete

DESCRIPTION	CONTENT (in %)	COMPRESSIVE STRENGTH (in M Pa)	
		7 days	28 days
CONTROL MIX	0	20.73	27.84
JFRC	1	14.10	25.66
E WASTE RC	15	23.87	35.50

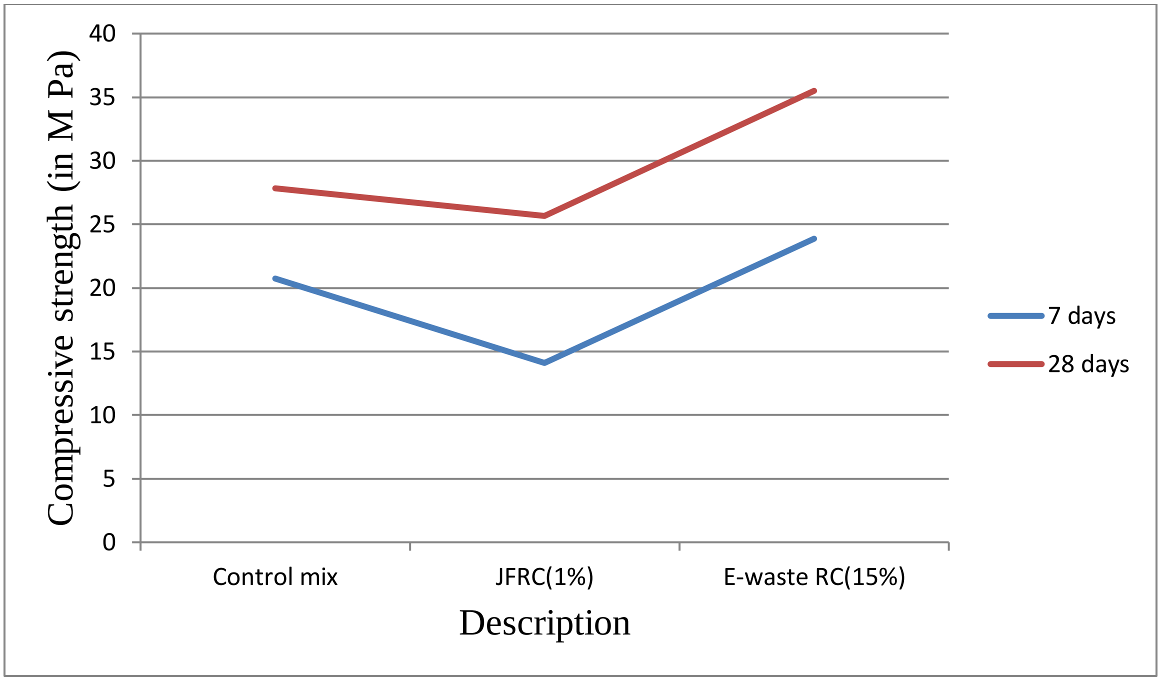

Fig 5.7 Comparison of compressive strength

5.6.2 COMPARISON OF SPLIT TENSILE STRENGTH

The test results obtained during split tensile strength test for 7 days and 28days of jute fibre and e-waste reinforced concrete of 1% jute and 15% e-waste are tabulated in the table 5.33

Table 5.33 Split tensile strength test results of 1% jute and 15% E-waste reinforced concrete

DESCRIPTION	**CONTENT (in %)**	**SPLIT TENSILE STRENGTH (in M Pa)**	
		7 days	**28 days**
CONTROL MIX	0	1.98	3.34
JFRC	1	2.39	3.55
E WASTE RC	15	2.85	3.81

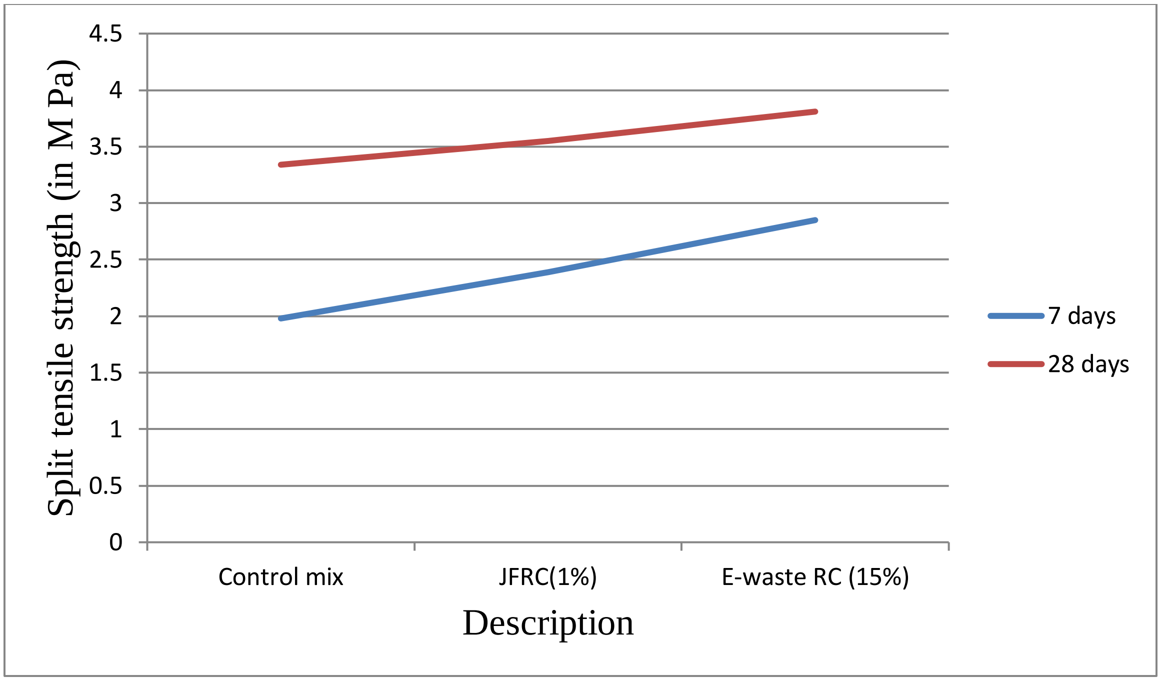

Fig 5.8 Comparison of split tensile strength

5.6.3 COMPARISON OF FLEXURAL STRENGTH

The test results obtained during flexural strength test for 7 days and 28days of jute fibre and e-waste reinforced concrete of 1% jute and 15% e-waste are tabulated in the table 5.34

Table 5.34 Flexural strength test results of 1% jute and 15% E-waste reinforced concrete

DESCRIPTION	CONTENT (in %)	FLEXURAL STRENGTH (in M Pa)	
		7 days	28 days
CONTROL MIX	0	3.20	4.40
JFRC	1	3.60	4.80
E WASTE RC	15	5.75	6.38

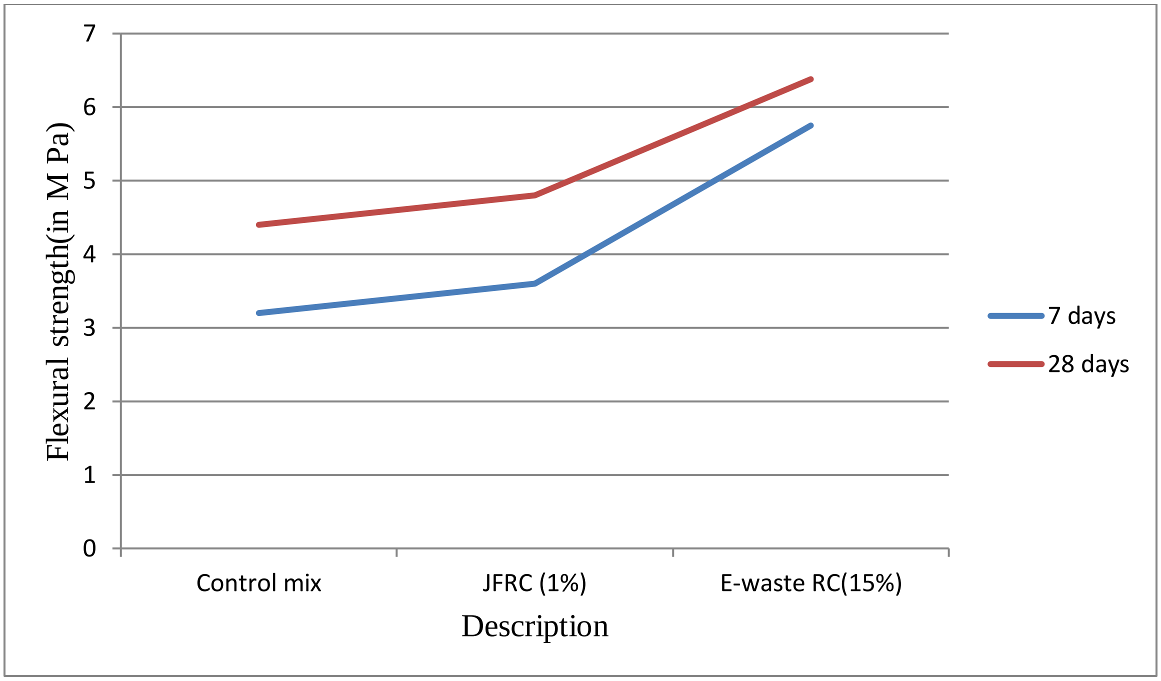

Fig 5.9 Comparison of flexural strength

5.7 TEST RESULTS ON JUTE AND E WASTE REINFORCED CONCRETE

5.7.1 COMPRESSION TEST

The test results obtained during compressive strength test for 7 days and 28days jute fibre reinforced concrete of 1% jute and different proportions of e-waste are tabulated in the table 5.35

Table 5.35 Compressive strength test results of 1% jute and different proportions of E-waste reinforced concrete

DESCRIPTION	CONTENT(in %)		COMPRESSIVE STRENGTH (in M Pa)	
	JUTE	E-WASTE	7 days	28 days
C1	1	5	19.85	30.65
C2	1	10	20.37	32.34

C3	1	15	22.35	34.35
C4	1	20	16.03	24.23

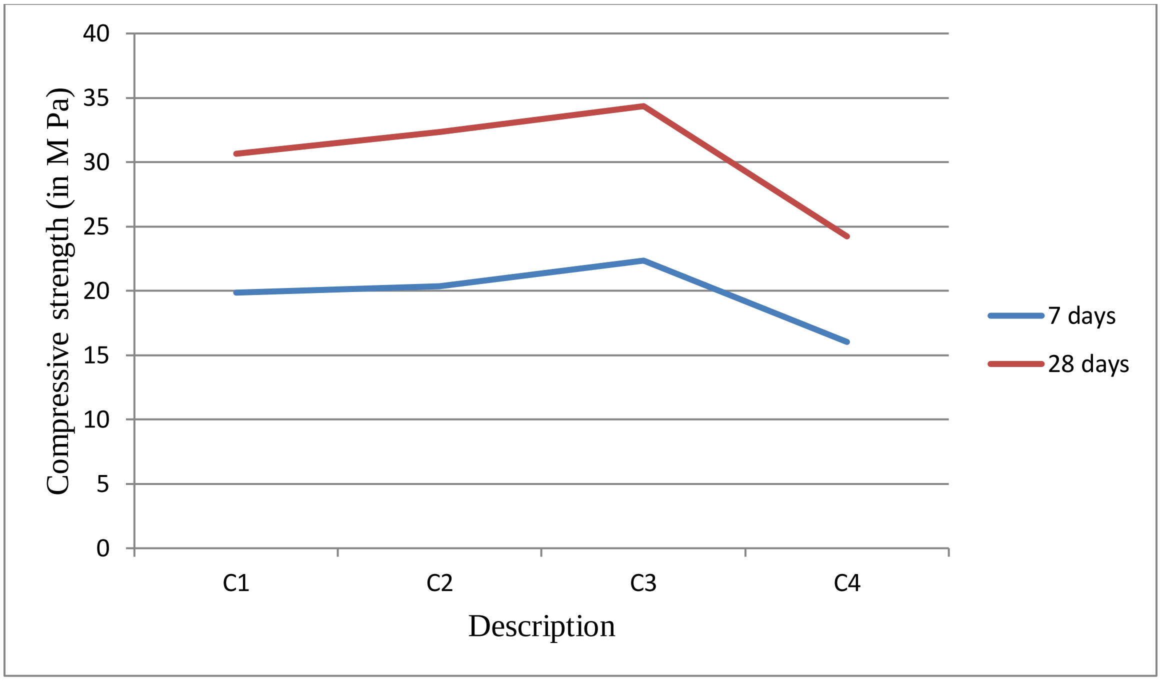

Fig 5.10 Comparison of compressive strength of 1% jute and different proportions of E-waste reinforced concrete

5.7.2 SPLIT TENSILE STRENGTH TEST

The test results obtained during split tensile strength test for 7 days and 28days jute fibre reinforced concrete of 1% jute and different proportions of e-waste are tabulated in the table 5.36

Area = 141.371x 10^3 mm^2

Table 5.36 Split tensile strength test results of 1% jute and different proportions of E-waste reinforced concrete

DESCRIPTION	CONTENT(in %)		COMPRESSIVE STRENGTH (in M Pa)	
	JUTE	E-WASTE	7 days	28 days
C1	1	5	2.57	3.48
C2	1	10	2.97	3.86
C3	1	15	2.79	3.73
C4	1	20	2.54	3.22

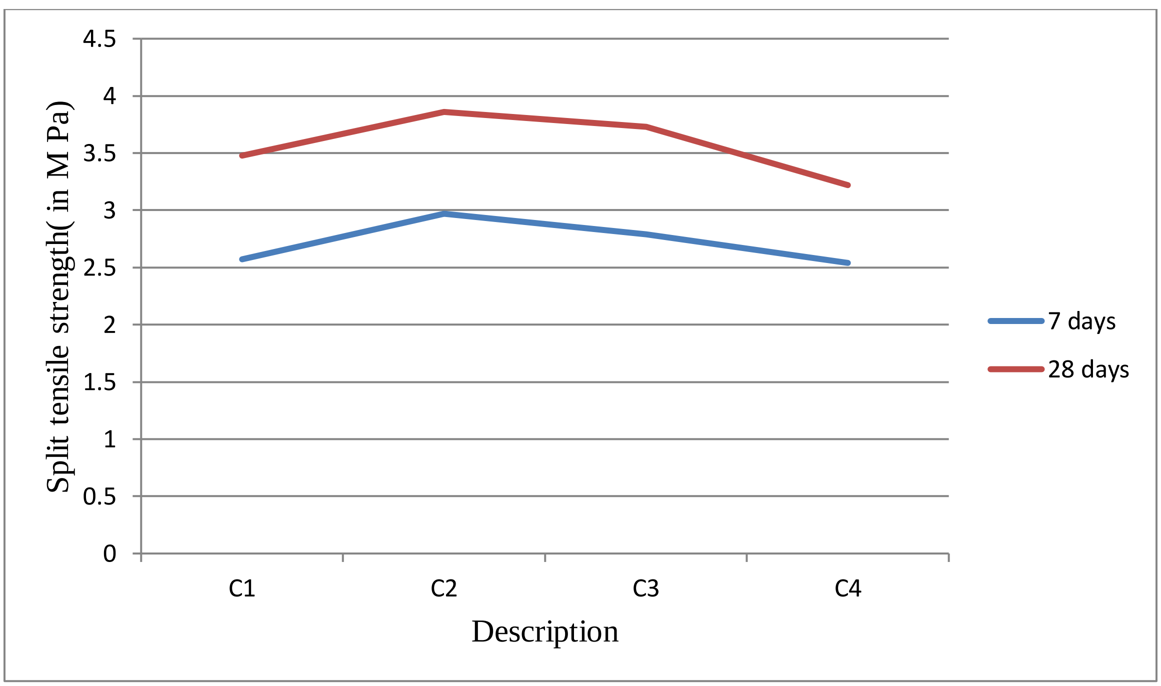

Fig 5.11 Comparison of split tensile strength of 1% jute and different proportions of E-waste reinforced concrete

5.7.3 FLEXURAL STRENGTH TEST

The test results obtained during flexural strength test for 7 days and 28days jute fibre reinforced concrete of 1% jute and different proportions of e-waste are tabulated in the table 5.37

Table 5.37 Flexural strength test results of 1% jute and different proportions of E-waste reinforced concrete

DESCRIPTION	CONTENT(in %)		FLEXURAL STRENGTH(in M Pa)	
	JUTE	E-WASTE	7 days	28 days
C1	1	5	4.10	4.93
C2	1	10	4.97	5.73
C3	1	15	5.12	5.90
C4	1	20	3.92	4.96

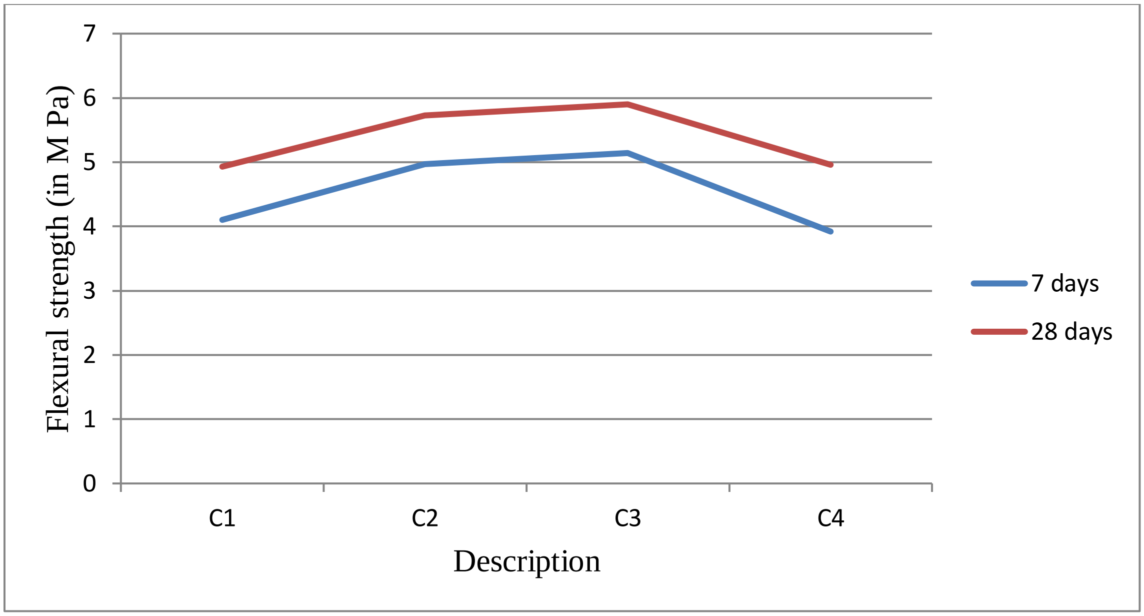

Fig 5.12 Comparison of flexural strength of 1% jute and different proportions of E-waste reinforced concrete

CHAPETR 6

CONCLUSION

6.1 DISCUSSIONS

Compressive strength increases up to 15% replacement of coarse aggregate with E-waste. This is because after 15% replacement the volume of E-waste proportion increases. As it is a flat particle the placing of E-waste in the concrete creates voids which are filled by the weak cement mortar.

Flexural strength of E-waste reinforced concrete increases up to 10% of replacement of E-waste by coarse aggregate. This is due to the reason that flexural strength increases with compressive strength and age of concrete.

6.2 CONCLUSION

- Flexural strength and split tensile strength of concrete increases up to 1% of jute loading and decreases with further increment.
- The addition of E-waste shows increase in compressive strength up to 15% replacement.
- Increase in split tensile strength is almost insignificant whereas gain in flexural tensile strength have occurred even up to 15 % replacements.
- 15% replacement of E-waste and jute fibers in concrete shows increase in compressive strength and flexural strength.
- On comparing the flexural strength of 15% replacement of E-waste in conventional concrete is 22% higher than that of 15% replacement of E-waste in 1% JFRC.
- On comparing the split tensile strength of 15% replacement of E-waste in conventional concrete is 4% higher than that of 15% replacement of E-waste in 1% JFRC.

- The use of E-waste in concrete is possible to improve its mechanical properties and can be one of the economical ways for their disposal in environment friendly manner.

REFERENCES

1) S. Manoj Kumar , Suchithra, Indu V, "Study on Replacement of coarse Aggregate by E-Waste" in concrete, International Journal of Technical Research and Applications.

2) N.Panneer selvam ,Gopala Krishna ,"Recycle of E-waste in concrete", International Journal of Science and Research (IJSR).

3) P.Krishna prasanna ,.Kanta Rao, "Strength variations in concrete by Using E-Waste as coarse aggregate" International Journal of Education and applied research.

4) S.P. Kale, H.I. Pathan, "Recycling of Demolished Concrete and E-Waste", International Journal of Earth Sciences and Engineering, Volume 4, Issue 1, 789-792, January 2015.

5|) Lakshmi, R. and Nagan, S. (2011) „Investigations on durability characteristics of e-plastic waste incorporated concrete‟ Asian journal of civil engineering, building and housing vol. 12 No. 6, pp. 773-787.

6) Sai vijaya krishna , B. Manoj Yadav, "A comparative study of jute fibre reinforced concrete"with plain cement concrete, IJRET: International Journal of Research in Engineering and Technology.

7) Vipul Kumar (2015) Study of cement composites on addition of jute fiber . International journal of research and technology (IRJET),2,PP. 1073- 1075.

8) Mohd usma, Priyanka Goel , Sandeep Panchal, “Experimental study of jute fibre reinforced concrete” Internationl journal of Advanced Technology in Engineering and Services.

9) Mohammad Zakaria, Mashud Ahmed, Md. Mozammel Hoque, Abdul Hannan. (2015). Effect of jute yarn on the mechanical behavior of concrete composites.

10) Gopi Raval , Maulik Kansagra, “Effects of Jute Fibres on Fibre-Reinforced concrete”, International Journal of Innovative and Emerging Research in Engineering.

11) ASTM D570-98, Standard Test Method for Water Absorption of Plastics, ASTM International, West Conshohocken, PA, 1998, www.astm.org.

12) IS: 4031 (Part 4)–1988. Methods of physical tests for hydraulic cement. Part 4. Determination of consistency of standard cement paste. Bureau of Indian Standards. New Delhi, India, Reaffirmed; 2005.

13) IS: 4031 (Part 5)–1988. Methods of physical tests for hydraulic cement. Part 5. Determination of initial and final setting Times. Bureau of Indian Standards. New Delhi, India, Reaffirmed; 2005.

14) IS: 4031 (Part 6) -1988. Methods of physical tests for hydraulic cement, Part 6, Determination of compressive strength of hydraulic cement other than masonry cement, Bureau of Indian Standards (2003), New Delhi, India, Reaffirmed; 2000.

15) IS, IS-516-1959. Methods of tests for strength of concrete. Bureau of Indian Standards New Delhi, India, Reaffirmed; 2004.

16) IS: 5816 – 1999. Method of test for splitting tensile strength of concrete, Bureau of Indian Standards (1999), New Delhi, India, Reaffirmed; 1999