Enhancing the Durability Properties of Jute Fiber Concrete Composites

P.Vijaya Kumar[1] M.M.Saravanan[2] Dr.M.Sivaraja[3]
[1]P.G. Student [2]Assistant Professor [3]Professor and Principal
[1,2]Department of Civil Engineering
[1,2]Kongu Engineering College, Erode, India [3]N.S.N College of Engineering and Technology, Karur, India.

Abstract— In this present study contracts with the thought of fiber reinforced concrete using jute fiber. The combination of fiber in concrete is an aboriginal subject. Concrete made of cement is strong in compression but weak in tension and also this concrete has little resistance to cracking which limits its use. These restrictions can be overcome by blending the concrete with fibrous material, which is termed as fiber reinforced concrete. With the modern technology, natural fibers like jute, bamboo, wool etc. can be economically extracted from various vegetables and animals. The addition of little strictly spaced and consistently dispersed fibers will improve the overall structural performance of the concrete. Due to ever increasing quantities of waste materials from industrial, solid waste management is the major fear in the world. Lack of land-filling space and because of its ever increasing cost, recycling and utilization of industrial by-products and waste materials has become an attractive proposition to disposal. One such manufacturing by-product is Rice Husk Ash (RHA). RHA is a major by-product of rice mills and successfully used as a land filling material for many years. Also the waste disposal has become one of the major problems in modern period. Either burning or land filling techniques is used to dispose the waste. Both of these techniques are hazardous to the environment. So adding of these waste fibers and RHA in concrete could help to save the environment. In this study, Jute fibers are added 0.5% volume fraction of concrete and rice husk ash is replaced by cement at various dosages like 0, 10%, 20% and 30% in concrete. This study includes the strength characteristics of the jute fiber and rice husk ash concrete investigate the mechanical properties like compressive strength, split tensile strength.

Key words: Natural Fiber, Jute Fiber, Rice Husk Ash, Acid Attack, Chioride Attack, Durability Strength

I. INTRODUCTION

Concrete is considered as one of the most versatile building material. Concrete has a relatively low tensile strength and low ductility when compared to other building materials. And also it is susceptible to cracking. The production of concrete leads to many environmental issues related to the significant release of CO2 and other greenhouse gases. Mainly, steel reinforcement in the form of bars, mesh or wires, is always used to meet tensile strength and ductility demands of concrete structures. The corrosive nature of steel under certain conditions limits its uses. Thus, it is essential to utilize the sustainable concrete and structures to reduce the harmful impact on the environment. The fusion of concrete with fibers is a conventional technique. Straw and asbestos are the few fibers that are being used in making of mud bricks and clay pots respectively since from the early ages. Natural fibers have the potential to be used as reinforcement to overcome the deficiencies in concrete material composites. In the recent times glass, steel and synthetic fibers like polypropylene plays a vital role in concrete industry. But the most sustainable and durable type of fiber which can be used in concrete with the less harmful effects on nature is natural fiber. These are extracted from various living beings and plants, with the help of modern technology. With use of natural fibers, the cost-effective and sustainable building construction is possible. It is found that natural fibers of different structure can be used to alter conventional steel rebar as reinforcement of concrete structures. By Adding of these natural fibers to concrete helps to improves various types of mechanical performances such as flexural properties, fracture toughness and impact resistance. More over the application of these natural fibers is beneficial for consuming less energy, releasing less greenhouse gases into the atmosphere, and costs less to build and to maintain over time. Fiber reinforced concrete (FRC) is another technology which yields similar properties as that of usual conventional concrete. Basically the Conventional concrete is brittle and has poor resistance to crack opening. Many journals showed that use of Jute fibers in lower strength concretes increase the compressive strength significantly when it is compared to plain un-reinforced matrices and is irectly related to volume fraction of Jute fiber used. This study provides in-depth look into the jute fiber reinforced concrete properties like durability, tensile strength, compressive strength and flexural strength.

II. MATERIALS

A. Jute Fiber:

Jute fiber is produced from genus Corchorus, family Tiliaceae. It is a long, soft and shiny vegetable fiber having off-white to brown color. High tensile strength and low extensibility are some key properties of jute fiber.

S.No	Physical Property	
1	Density (G/Cm^3)	1.4
2	Length (Mm)	30
3	Diameter (Mm)	0.15 – 0.20
4	Aspect Ratio	150 - 300
4	Elongation At Break (%)	1.7
5	Cellulose Content (%)	50 – 57
6	Lignin Content (%)	8 – 10
7	Young's Modulus (Gpa)	30

Table 1: Physical Properties of Jute Fiber

Fig. 1: Treated Jute Fiber

B. Rice Husk Ash:

Rice husk was burnt approximately 48 hours under uncontrolled combustion process. The ash so obtained was ground in a ball mill by box-behnken methodology and its appearance was grey. From the chemical composition it is clear that the principal material contained in RHA is SiO2 and it contains 7.27% loss on ignition which is an indication of its carbon content. The RHA also contains high K2O content which is due to fertilizers. For normal RHA, silica content is about 82.89% and loss on ignition is 7.27%.

C. Cement:

Ordinary Portland cement of 53 grade conforming to IS: 8112 – 1989 was used. Its specific gravity was 3.15.

III. METHODOLOGY

Concept of using jute fiber in concrete was conceived. Based on the concept, various papers where referred and a knowledge about the natural fiber known as the jute fiber being used in concrete was obtained. The knowledge on fiber reinforced concrete was also found by referring various journals. Literature review was done and the concept was finalized. Various tests on Binding Material, fine and coarse aggregates were carried out and the results were achieved. In order to do find the value or drawback of any special concrete, it has to be related with conventional concrete. Therefore, a set of conventional concrete mix specimen is required. In order to cast a set of conventional concrete mix, primarily the mix design for M40 grade of concrete has to be done. Tests on fresh concrete were carried out. Workability was tested by slump test. The water binder ratio and the percentage of super plasticizer to be added was also firm based on three altered designs of trail mix. The mix with optimum results were considered for casting conventional concrete mix. The similar mix ratio which was used to cast conventional concrete mix specimen, was used to cast special concrete mix specimens. Special concrete mix specimens are fiber reinforced specimens. Fiber was cut for aspect ratio. For the aspect ratio, 0.5 percentage of amount of fiber were added to concrete mix. Special concrete specimens consist of cubes, cylinders and prisms. OPC grade 53 cement was used in casting. The coarse aggregate added to the mix was divided into two portions. 50% of 20mm aggregate and 50% of 12.5mm aggregate was used. Jute Fiber reinforced Concrete were cast and acid curing of 28 and 56 days specimen testing were carried out to find the compressive strengths and weight loss percentage for the concrete.

A. Mix Proportion:

The work on M40 grade of concrete as per IS:456-2000 for fiber-cement ratio 0.5% are carried out with fiber length of 25mm – 30mm chopped. The conventional mix proportion concrete composed of cement (350 kg/m3), fine aggregate (717 kg/m3), coarse aggregates (1356 kg/m3) and water to cement ratio is 0.4. The addition of jute fiber into conventional mix concrete is 0.5% of concrete volume fraction. The addition of Rice Husk Ash into conventional mix concrete is 5%, 10%, 15% of cement volume fraction. The Mix ID for corresponding conventional mix, 0.5% jute fiber + conventional mix, 0.5%JF + 5%RHA replace with cement, 0.5%JF + 10%RHA replace with cement, 0.5%JF + 15%RHA replace with cement are CC, JFC, RJ1, RJ2, RJ3 respectively.

IV. DURABILITY TESTS ON CONCRETE

The ability of concrete to resist weathering action, chemical attack, abrasion resistance and also to withstand the conditions for which it is designed without deterioration for a long period of years is known as durability. For the measurement of durability resistance of mixes, following tests were performed.

- Acid attack on concrete
- Chloride attack on concrete
- Rapid chloride penetration test (rcpt) on concrete

The experimental investigation was carried out on the specimen to study the durability properties of concrete containing 5%, 10% and 15% RHA. The cube specimen of size 100 mm x 100 mm x 100 mm, cylinder specimen of 100 mm x 50 mm for RCPT test and prism of 100 mm x 50 mm x 50 mm was casted. After 28 days curing, the specimen was immersed in the respective acids for about 56 days.

A. Acid Attack On Concrete:

The acid attack was carried out on cubes of size 100 mm x 100 mm x 100 mm. The concrete cubes were dried in normal room temperature of 27°c ± 2°c after 28 days of curing, the specimens were taken out and allowed to dry for one day and the weight (W1) of cubes was noted. The sulphuric acid solution was prepared by adding 1.0% sulphuric acid of 1N (by volume of water) to 20 liters of distilled water. The concrete cubes were then immersed in 1.0% sulphuric acid solution for a period of 56 days. The concrete specimen immersed in acid solution is shown in figure 2.

Fig. 2: Concrete specimen immersed in acid solution

B. Chloride Attack on Concrete:

The chloride attack test was carried out on cubes of 100 mm x 100 mm x 100 mm. The concrete cubes were dried in normal room temperature of 27°c ± 2°c after 28 days of curing and the weight (W1) of cubes was noted. The sodium chloride solution was prepared by adding 3.5% sodium chloride salt (by volume of water) to 50 liters of distilled water. In this experimental study the concrete cubes were immersed in 3.5% sodium chloride (1N Nacl) solution for a period of 56 days. The observations were then made after 56 days from the date of immersion in the sodium chloride solution. The concrete specimen immersed in chloride solution is shown in figure 3.

Fig. 3: Concrete specimen immersed in chloride solution

C. Rapid Chloride Penetration Test (Rcpt) On Concrete:

The rapid chloride penetration test (RCPT) was performed as per ASTM C 1202 and the specimen of 50 mm long and 100 mm diameter was casted and cured at 28 days. The electrical conductance of the conventional concrete (M40) at the age of 28 days was determined. RCPT is a measure of electrical charge that travels between two sides of a concrete specimen over a six hour period. The test apparatus consisted of two reservoirs. The specimen was fixed between two reservoirs and one reservoir was filled with 0.3N sodium hydroxide solution and the other reservoir with three percentage of sodium chloride solution.

V. RESULTS AND DISCUSSION

The durability study was made on 0.5% jute fiber, 5%, 10% and 15% RHA with 0.5% JF concrete specimens. The results are tabulated below.

A. Acid Attack Test:

The acid attack generally occurs when calcium hydroxide present in the concrete gets exposed to the acidic substances in the surroundings. The acidic substances both mineral acidic substances and organic acidic substances are the most aggressive agents inducing the acid attack on the concrete. The acid attack on the concrete occurs at values of pH below 6.5, a pH of less than 4.5 leading to severe acid attack. The weight loss and compressive strength of the specimen at 56 days before and after immersion of the specimens were found out. The percentage decrease in weight and compressive strength of the specimen under acid test is shown in figure 4 and figure 5.

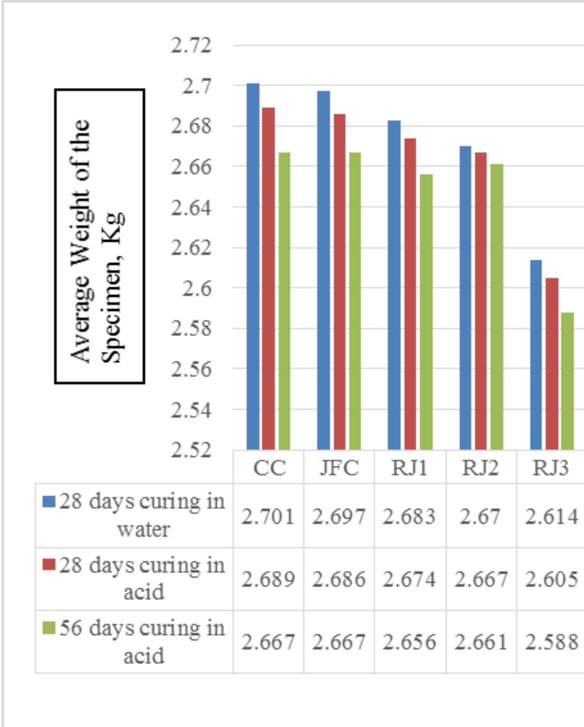

Fig. 4: Average weight of the specimen under acid test after 28 days and 56 days

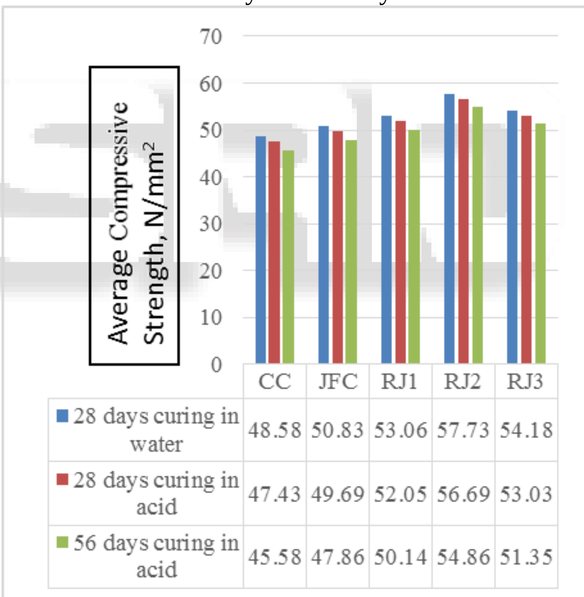

Fig. 5: Average compressive strength of the specimen under acid test after 28 days and 56 days

B. Chloride Attack Test:

The chloride attack on the concrete is important because it mainly induces the corrosion of reinforcement bar placed inside the concrete. It is observed that more amount of failure and collapse of structures are due to corrosion of reinforcement bar placed inside the concrete. The weight gain and compressive strength of the specimen at 56 days before and after immersion of the specimens were found out. The percentage increase in weight and percentage decrease in compressive strength of the specimen under chloride test is shown in figure 6 and figure 7.

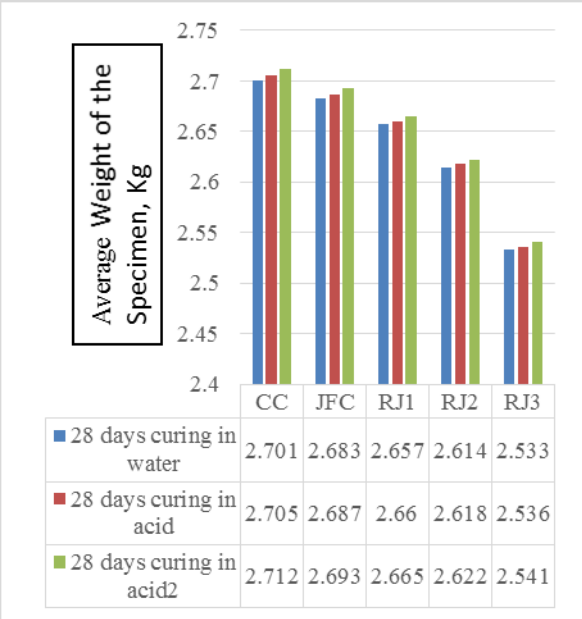

Fig. 6: Average weight of the specimen under chloride test after 28 days and 56 days

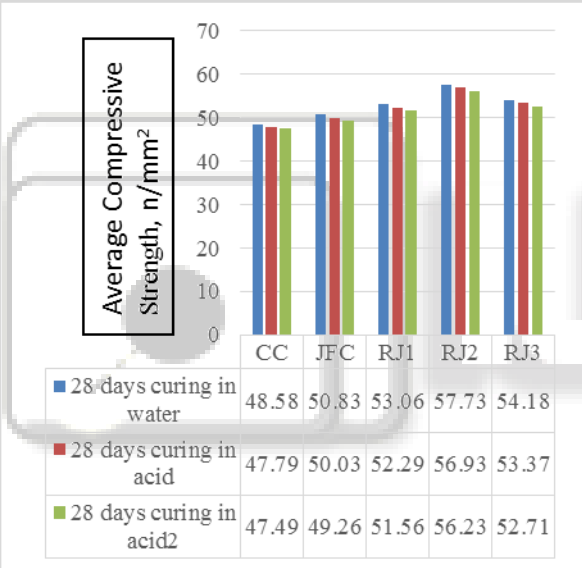

Fig. 7: Average compressive strength of the specimen under chloride test after 28 days and 56 days

C. Rcpt Test:

RCPT test is one of the important tests which determine the rate of chloride ion ingress into concrete. It is primarily dependent on the internal pore structure. The pore structure in turn depends on other factors such as the mix design, degree of hydration, curing conditions. The curing conditions and the age of the concrete thus largely determine the ease with which chloride ions can move into a concrete. The intensity of current was monitored periodically at 0, 30, 60, 120, 150, 180, 210, 240, 270, 300, 330, 360 minutes. The coulombs passed for different mixes are shown in figure 8.

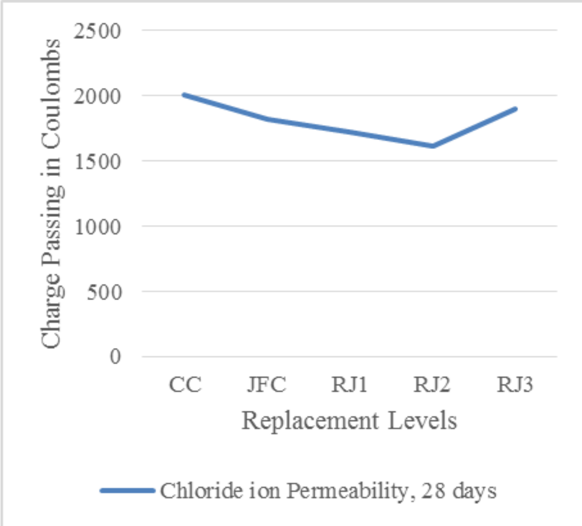

Fig. 8: Coulombs passed for different mixes at 28 days

VI. CONCLUSION

Use of RHA in concrete reduces the production of waste through industries. RHA is an eco-friendly building material. The problems of disposal and maintenance cost of land filling also reduced. RHA is much cheaper, therefore it is very economical. Based on the experimental results the following observations are made:

– There is only a minimum loss in weight and compressive strength of concrete for all the durability tests. Hence the mix with 0.5% BF and 10% RHA shows better results under durability tests.
– Use of RHA in concrete solves the disposal problems thereby by reducing the land pollution. So from economical point of view, rice husk ash can be used as a replacement of cement up to 30% without any adverse effect on the strength of concrete. Also the addition of basalt fiber enhances flexural strength and stiffness of a material. Thus concrete with RHA and BF can be applied to produce high performance concrete.

REFERENCE

[1] M.A.Aziz and M.A.Mansur, "Jute Fiber Reinforced Concrete Materials for Building Construction", IABSE Congress Report 1988, Vol. 13, pp. 116-122.
[2] Jaspal Singh et al, "Sustainable Concrete Using Natural Fiber a Review", Journal of International Academic Research for Multidisciplinary 2015',Vol. 3, Issue. 9, pp. 36-46.
[3] J.Kim et al, "An Investigation of Mechanical Properties of Jute Fiber-Reinforced Concrete", RILEM Publications 2012, Vol. 6, pp. 75-82.
[4] Majid Ali, "Natural fibers as construction materials", Journal of Civil Engineering and Construction Technology 2012, Vol. 3(3), pp. 80-89.
[5] G.Ramakrishna et al, "Evaluation of Durability of Natural Fiber Reinforced Cement Mortar Composite- A New Approach", ARPN Journal of Engineering and Applied Sciences 2010, Vol. 5, No. 6, pp. 44-51.
[6] Saandeepanivajje and Dr.N.R.Krishnamurthy, "Study on Addition of the Natural Fibers into Concrete", International Journal of Scientific & Technology Research 2013, Vol. 2, Issue. 11, pp. 213-218.

[7] TaraSen,H.N.JagannathaReddy, “Application of Sisal, Bamboo, Coir and Jute Natural Composites in Structural Up gradation”, International Journal of Innovation, Management and Technology 2011, Vol. 2, No. 3, pp. 186-191.
[8] IS: 456-2000, Indian Standards-Mix Design.
[9] IS 10262-2009, Indian Standard Specifications for Mix Design.
[10] IS: 383-1970-Indian Standards for Aggregate Proportioning.