EXPERIMENTAL STUDY ON FERROCEMENT USING JUTE FIBERS AND STARCH

Smiline Shiny .D
Assistant Professor, Dept of Civil Engineering,
91-9043109861, smilineshiny@gmail.com

Jerlin Regin .J
Associate Professor, Dept of Civil Engineering,
91- 9486672875, jerlin_regin2003@yahoo.com

Jemi Mercilin .J, Neegitha R.S
UG Student, Dept of Civil Engineering,
St. Xavier's Catholic College of Engineering, Chunkankadai.

Abstract- **Ferrocement is a reinforced mortar applied over a layer of metal mesh. Ferrocement can be used widely in the construction of hulls of boats, shell roofs, and water tanks. Hence ferrocement has a wide range of applications and it can be also used in the construction of roof slabs, lintels, and so on. In this experimental investigation, 10% percentage of starch is added with water in the mixture. The steel mesh is used as the reinforcement in ferrocement. Also jute fibers of length 20 mm are cut and added to the mixture by 0.5%, 1%, and 1.5% of the total volume as secondary reinforcement. The specimens are casted, and the experimental results are compared and investigated along with the normal conventional cement mortar mix. Addition of 1.5% of jute fibers and 10% of starch to the mixture increase the Compressive strength, Split tensile strength and Bending strength by 10.5%, 8%, 14.5% respectively. This proves that Ferrocement with jute fibers and starch can be effectively used for construction.**

Keywords- Ferrocement, Starch, Jute Fibres.

I. INTRODUCTION

Ferrocement construction technology is quite popular throughout the world. Ferrocement or ferro-cement is a system of reinforced mortar or plaster consisting lime or cement, sand and water applied over layer of metal mesh, woven expanded-metal or metal-fibers and closely spaced thin steel rods such as rebar. The metal commonly used is iron or some type of steel. It is used to construct relatively thin, hard, strong surfaces and structures in many shapes such as hulls for boats, shell roofs, and water tanks [1].

The reinforcing mechanism in ferrocement not only improves many of the engineering properties of the brittle mortar, such as fracture, tensile and flexural strength, ductility, and impact resistance, but also provides advantages in terms of fabrication of products and components [2]. The present authors recommend that the experimental investigation may be conducted on new reinforcing materials by researchers in the future. The study concludes that the ferrocement will certainly be one of the best structural alternatives for RCC in the future.

Ferrocement is a thin construction element with thickness in the order of 10-25 mm and uses rich cement mortar; no coarse aggregate is used; and the reinforcement consists of one or more layers of continuous small diameter steel wire weld mesh netting. It requires no skilled labor for casting and employs only little or no formwork. In ferrocement, cement matrix does not crack since cracking forces are taken over by wire mesh reinforcement immediately below the surface. The strength of ferrocement depends on the following two factors namely, quality of sand and cement mortar mix and quantity of reinforcing materials used. The advantage of ferrocement is that they can be fabricated into any desired shapes.

In this present investigation, Jute fiber has been used as a secondary reinforcement along with the steel mesh as the main reinforcement to increase the strength. Starch is used as binding materials thereby incorporating a waste material in construction. The addition of jute fibers is observed to increase the strength of ferrocement slabs which can be efficiently used for the construction of wall panels, partition walls etc. Starch increases the durability, viscosity and reduces the slump of the ferrocement mixture which is efficient for construction.

II. MATERIALS USED

Cement

Cement of grade OPC 53 is used. OPC 53 Grade cement is required to conform to BIS specification IS: 12269-1987 with a designed strength for 28 days being a minimum of 53 MPa or 530 kg/cm^2. Not only this grade of cement stronger than other grades or types, is it also more durable.

Fine Aggregate

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 groundededges, washed and graded to as a construction material. The size of manufactured sand (M-Sand) is less than 4.75mm.

Water

Potable water is used for making cement mortar. The pH value of water lies in between 6.5 to 8.5 which indicate that the water is free from organic matters.

Steel Mesh

Steel mesh reinforcement is broadly used as the main and characteristic reinforcing for industrial concrete floor slab, shotcrete. It is also measured for structural purposes in the reinforcement of water tanks, tunnel segments, concrete cellars, meshes help to develop the compressive, tensile and flexural strength, post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eliminates temperature and shrinkage cracks. The main reason for addition of meshes to mortar is to develop the post cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent flexure.

Jute Fibers

Jute is a bast fiber used for sacking, burlap, and twine as a backing material for tufted carpets. It is a long, soft, shiny fiber that can be spun into coarse, strong threads. It is one of the cheapest natural fibers, and is second only to cotton in amount produced and variety of uses. Recent studies have shown that jute fiber delays the hardening of concrete and improves the resistance of concrete against cracking (3). Jute fibers with four different cut lengths (10, 15, 20, and 25 mm) were applied with various volumetric percentages on concrete mixture. The incorporation of jute fiber as a constitutive material of concrete affects the rheological properties of the fresh concrete. In this experiment, jute fibers of length 20 mm were cut and mixed with cement which improved the compressive strength by at least 10 %.

Starch:

Starches and its derivatives are known to exhibit viscosity modifying characteristics. Rice water is the suspension of starch obtained by draining boiled rice or by boiling rice until it completely dissolves into the water (4). A major advantage of starch is that it is a renewable material that has varieties of industrial applications because it is inexpensive and environmentally friendly. In ferrocement, starch is used to increases the binding strength and workability.

III.TESTING OF MATERIALS

Casting

Preparation of Moulds

The moulds of cubes, cylinders and slabs are cleaned, and the dusty sand particles are wiped out. Oil is applied in the inner sides of the moulds and the moulds are kept ready for filling with mortar mix.

Figure 1 Preparation of Moulds

Preparation of mortar

Mortar was prepared by calculating the exact amount of cement, sand and water by considering the appropriate mix design and water-cement ratio. At first the cement and sand were mixed dry. Water is gradually added to the dry mix and is mixed by using shovel.

Preparation of mesh

The mesh was cut in to the dimensions of the slab as 500 x 250 mm. The bending was straightened by using wooden hammers.

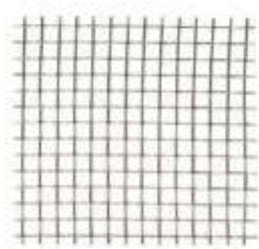

Figure 2 Preparation of mesh

Casting

The cubes, cylinders and slabs were cast using the closed mould system. The mortar is applied from one side through several layers of mesh, held in position against the surface of a closed mould. The mould is treated with mould releasing agents. In this method, the mortar is applied from one side.

Curing

The day-old mortar specimens were cured by wet curing for a period of 28 days. The specimens were laid for curingafter the specimens were marked legibly with a permanent marker for identification.

IV. TESTING OF HARDENED SPECIMENS

The mechanical properties of the hardened specimens are determined by performing compressive strength, split tensile and bending strength tests and the results are described.

Compressive Strength Test

Compressive strength of mortar is determined by using 70.6 mm cubes. The 14 and 28 days old cured specimens were dried for 24h and are tested.

$$\text{Compressive Strength} = \frac{Load}{Area}$$

Split Tensile Strength Test

Split tensile strength of cylinder is determined by using cylinders of diameter 100 mm and height 200 mm. The 28 days old cured specimens were dried for 24h and are tested.

$$\text{Split tensile strength} = \frac{2P}{\pi DL}$$

Bending Strength Test

The bending strength test is performed on slabs of size 500 mm x 250 mm x 30 mm. The 28 days old cured specimens were dried for 24 h and are tested.

$$\text{Bending Strength} = \frac{Pl}{bd^2}$$

V. RESULTS AND DISCUSSIONS

Material Testing

Fineness of Cement

As per Indian standard the residue of *cement* should not exceed 10% when sieved on a 90 micron IS sieve. In addition, the amount of water required for constant slump concrete decreases with increases in the *fineness of cement*. The calculated fineness is 8% which is within the limits.

Specific Gravity of Cement

The obtained specific gravity of cement is **3.15 .**For Nominal mix design, the specific gravity of cement should be 3.15g/cc.

Specific Gravity of Fine Aggregate

Specific gravity of fine aggregate is **2.6.** The specific gravity of sands is considered to be around 2.65.Therefore the specific gravity of sand is within the limiting value (7).

Sieve Analysis of Fine Aggregate

Fineness modulus of fine aggregate is **3.58.** The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fineness modulus.

Results of Compressive strength Compressive Strength at 14 days

For the normal mix of cement : sand ratio 1:2.5,the nominal compressive strength for cube specimens was observed to be 18.05 N/mm^2.By adding 0.5 % jute fiber and 10 % starch to the normal mix, the compressive strength for cube specimens was 13.77 N/mm^2. By adding 1% jute fiber and 10 % starch to the normal mix, the compressive strength for cube specimens was 16.01 N/mm^2.The reduction in the strength results are due to addition of jute fibers in small quantities. Addition of 1.5 % jute fibers and 10% starch to the normal mix gave a compressive strength of 18.89%, which is greater than the strength of normal mix by 5%.

Compressive Strength at 28 days

For the normal mix of cement : sand ratio 1:2.5,the nominal compressive strength for cube specimens was observed to be 21.1 N/mm^2.By adding 0.5 % jute fiber and 10 % starch to the normal mix, the compressive strength for cube specimens was 17.28 N/mm^2. By adding 1% jute fiber and 10 % starch to the normal mix, the compressive strength for cube specimens was 20.3 N/mm^2.Addition of 1.5 % jute fibers and 10% starch to the normal mix gave a compressive strength of 23.3%, which is greater than the strength of normal mix by 10.5%.

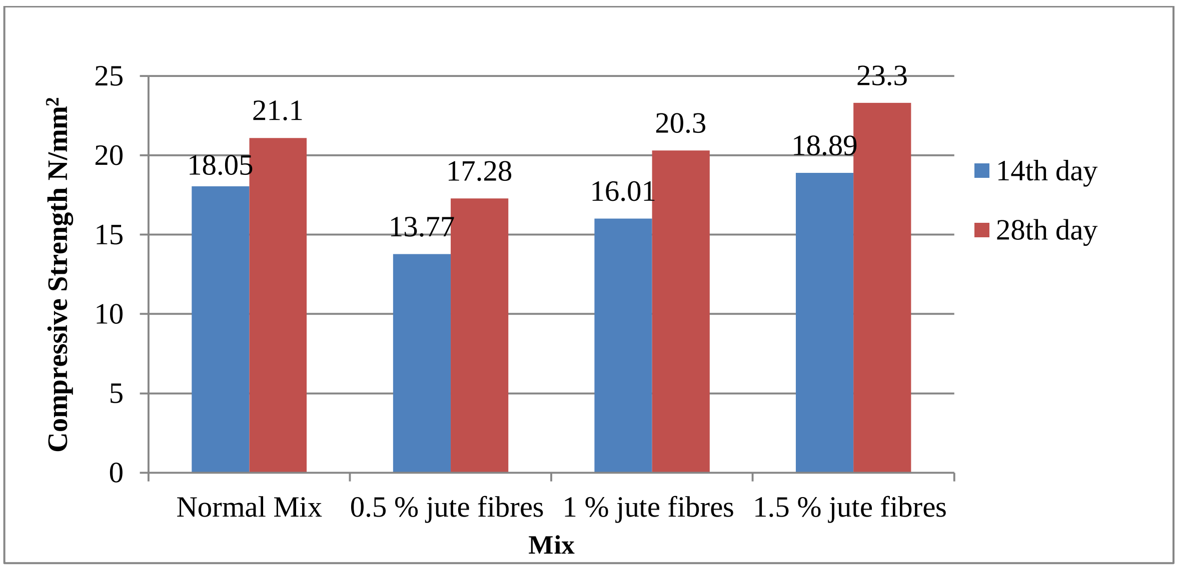

Figure 3. Variation of Compressive Strength

Results of Split Tensile Strength Split Tensile Strength at 28 days

For the normal mix of cement : sand ratio 1:2.5,the nominal split tensile strength for cylinder specimens was observed to be 2.06 N/mm^2.By adding 0.5 % jute fiber and 10 % starch to the normal mix, the split tensile strength for cylinder specimens was 1.44 N/mm^2. By adding 1% jute fiber and 10 % starch to the normal mix, the split tensile strength for cylinder specimens was 1.76 N/mm^2.Addition of 1.5 % jute fibers and 10% starch to the normal mix gave a split tensile strength of 2.23 N/mm^2, which is greater than the strength of normal mix by 8.25 %.

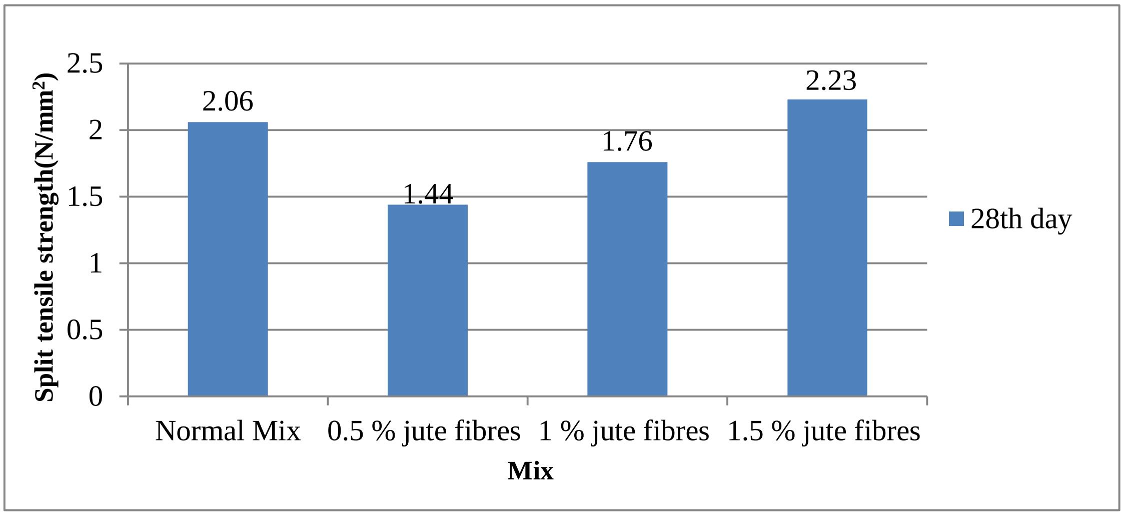

Figure 4. Variation of Split Tensile Strength

Results of Bending Strength Bending Strength at 28 days

For the normal mix of cement : sand ratio 1:2.5,the nominal bending strength for slabs was observed to be N/mm^2.By adding 0.5 % jute fiber and 10 % starch to the normal mix, the bending strength for slabs was 22.28 N/mm^2. By adding 1% jute fiber and 10 % starch to the normal mix, the bending strength for slabs was 24.88 N/mm^2.The reduction in the strength results are due to addition of jute fibers in small quantities. Addition of 1.5 % jute fibers and 10% starch to the normal mix gave a bending strength of 30.55%, which is greater than the strength of normal mix by 15%. This increase in strength is observed due to the increase in the quantity of jute fibers.

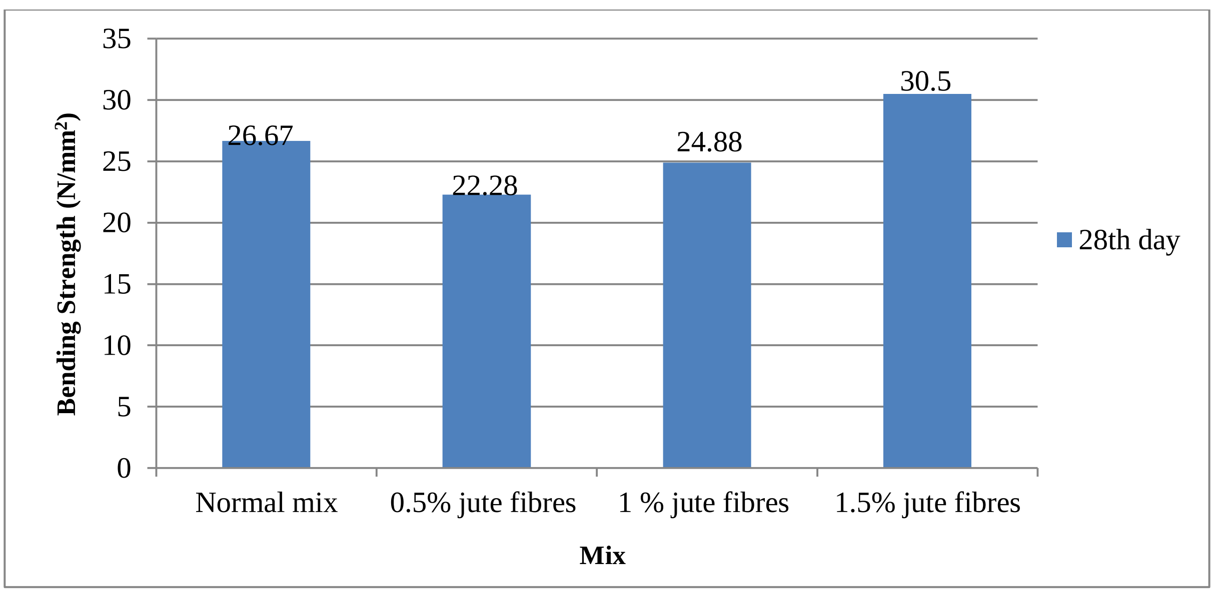

Figure 5. Variation of Bending Strength

VI. CONCLUSION

Based on the experimental investigations the following conclusions are obtained,

The addition of jute fibres by 1.5% and 10 % starch in ferrocement cube specimens increases the compressive strength by 10.5% as compared to conventional mix. The cylinder specimens with 1.5 % jute fibres and 10 % starch increases the split tensile strength by 8 % when compared with the normal mix. Slabs with 1.5 % jute fibres and 10 % starch increases the bending strength by 14.5 % when compared with the normal mix. The slab having the highest flexural strength is economical than the conventional ferrocement slab.

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