An experimental study on flexural strength and corrosion properties of RCC with sisal fibre

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Abstract - *Concrete is one of the most durable building materials. Sometimes, the exposure condition of environment may affect the properties of concrete. One of the most current degradation of reinforced concrete structure is related to the corrosion of reinforcement in concrete. Corrosion of reinforcement is a major problem which influences the long term performance of the reinforced concrete structures. It adversely affects the durability of the concrete structures. Quality of concrete, cover thickness of concrete reinforcement, condition of reinforcement, effect of environment and other chemicals, porosity of concrete, effect of high thermal stress and freezing and thawing condition influence the corrosion in concrete structures. It is more important to understand the performance of corroded reinforced concrete under loading condition. The study is about the influence of corrosion of rebar in RCC with sisal fibre with different percentages 0%, 0.5%, 1% and 1.5%, also the degradation of bond between reinforcing steel and concrete and the crack profile developed under loading condition for normal concrete and concrete with sisal fibre of M30 grade. The corrosion is induced in steel rebar by using an electrochemical accelerated corrosion technique in each test specimens. The crack opening width was recorded after the corrosion process.*

Key Words: Accelerated corrosion technique, Rebar, Durability, Crack width, Sisal fibre.

1. INTRODUCTION

Concrete is a composite material composed of cement, fine aggregate, coarse aggregate and water and widely used for construction. In order to achieve the desired physical properties of the finished material, certain additives and reinforcement are added to the plain cement concrete. It is to be understood that the plain cement concrete has relatively low tensile strength and durability as compared to the reinforced cement concrete. Concrete alone is good in compression, but reinforced concrete greatly increases the scope for making structures required to withstand other forms of mechanical force. The reinforcement is usually steel reinforcement and passively embedded in concrete before concrete sets. The reinforcements are designed in concrete for resisting the tensile stresses developed in any region that cause unexpected cracking and structural failures. Reinforced concrete is used in numerous ways, some of the larger and better known uses including roadways, bridges, car parks, residential buildings and in industry. Recently the aspects of concrete durability and performance have become a major subject of discussion especially when the concrete is subjected to a severe environment. Sometimes, the exposure condition of environment may affect the properties of concrete. One of the most current degradation of reinforced concrete structure is related to the corrosion of reinforcement in concrete. Corrosion of reinforcement influences the long term performance and durability of reinforced concrete structures. The studies reveal that corrosion products of steel expand seven times that of original size and it induces expansive stresses around the corroded steel bars. It causes possible cracking, spalling of concrete covers and loss of bonding between the steel and concrete. The factors influencing the corrosion in concrete are quality of concrete, cover thickness, condition of reinforcement, porosity of concrete, effect of chemicals etc. The environment provided by good quality concrete to steel reinforcement is one of high alkalinity due to the presence of the hydroxides of sodium, potassium and calcium produced during the hydration reactions. This oxide film protects the concrete from corrosion to a greater extent. The permeability of the concrete is important in determining the extent to which aggressive external substances can attack the steel.

2. SCOPE AND OBJECTIVES

2.1 Scope of the study

Nowadays, the construction fields are facing the problem of corrosion in concrete. So it is more important to know how such concrete performs under loading conditions. Along with that, the assessment of condition of such concrete structures in order to determine the remaining service life and method of repair is also to be considered. Repair and rehabilitation of existing corroded structures is becoming a difficult part of the present construction activities. It substantially increases the cost of the construction and difficulties. In order to select suitable remedial measures it is necessary to make an assessment of the residual strength and the residual life. It is a great thing to prevent the spreading of cracks in the corroded concrete along with reducing the corrosion of rebar. The studies show that, the cracking in fibre reinforced concrete is less than that of RCC. The load required to achieve the same crack width in fibre reinforced concrete is found to be more as that of RCC. So, it will be effective to find whether the fibre reinforced concrete has the capacity to compensate the tensile strength which is lost by corrosion of bars or not. This paper presents a study about the influence of corrosion of rebar in RCC with sisal fibre and also the degradation of bond between reinforcing steel and concrete and the crack profile developed under loading condition for normal concrete and concrete with sisal fibre of M_{30} grade. The study will reveal whether the fibre provides tensile strength to the concrete or not, to compensate the lost tensile strength during corrosion. The sisal fibre is a natural fibre which is obtained from agave plant. So it is abundantly available.

2.2 Objectives of the study

The main objective of the study is to find whether the sisal fibre reinforced concrete has the capacity to compensate the tensile strength which is lost by corrosion of bars or not.

3. MATERIALS

Materials were selected and collected before the starting of the study. Then, the materials were tested to conform the IS specification.

3.1 Cement

Cement is a binder, a substance that sets and hardens independently, and can bind other materials together. In this study, the cement used was Ordinary Portland Cement (OPC) of grade 53 having specific gravity 3.15 and consistency 28%.

3.2 Aggregates

Coarse aggregates of 20mm size with specific gravity 2.68 were used. M sand having specific gravity of 2.35 was used as the fine aggregate.

3.3 Water

Water is an important ingredient of concrete as it actively reacts with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be considered very carefully.

3.4 Sisal fibre

Sisal fibre is one of the most widely used natural fibre and is obtained from sisal plant, known formally as Agave sisalana. These fibres are straight, smooth and yellow in color. Strength, durability and ability to stretch are some important properties of sisal fibres. To remove the wax and dirt in the fibre, it was subjected to alkali treatment (5% of NaOH solution).

Fig -1: Sisal fibre

Table -1: Properties of sisal fibre

Properties of fibre	Values
Fibre length	25mm
Fibre diameter	0.25mm
Aspect ratio	100
Tensile strength	268GPa
Elongation	14.8%
Young's modulus	42.5GPa

3.5 Rebar (Steel)

Reinforced concrete is a mixture of concrete and steel reinforcement. Concrete is weak in tension and cracks easily when it shrinks or creeps under sustained loading. It is a brittle material. When concrete fails, it breaks suddenly without warning. Steel, on the other hand, is 100 times stronger in tension than concrete; is 6 times stiffer; and will stretch 17 times more than concrete before failing. Steel reinforcement provides to reinforced concrete the tensile strength, stiffness, and ductility needed to make it an efficient, durable, versatile, and safe building material. But the existence of steel within the concrete is a major thing. The effect of corrosion in the embedded steel bars badly affect to their existence. In this work, steel of Fe_{415} with different diameters were used.

4. METHODOLOGY

4.1 Selection of mix proportion

M30 was selected as the grade of concrete. Since it is a design mix its mix proportion had to be done.

4.2 Material testing

Before casting the specimens, tests were conducted on materials to find its properties. The results are mentioned above.

4.3 Mix design

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. As per IS 10262:2000 the mix proportion was obtained as 1:2.08:3.13.

4.4 Workability test

By conducting the workability tests such as slump test and compaction factor test in the absence of admixture, the concrete was seemed to be not workable. Therefore, to increase the workability of concrete an admixture was added.

4.5 Casting of specimens

Concrete beams of size 15x22.5x100cm with four different percentages were cast. . A small portion of rebar was extended beyond the specimen to apply power supply to the specimen to increase the corrosion rate. As per IS 456:2000 minimum reinforcement was provided in the beams.

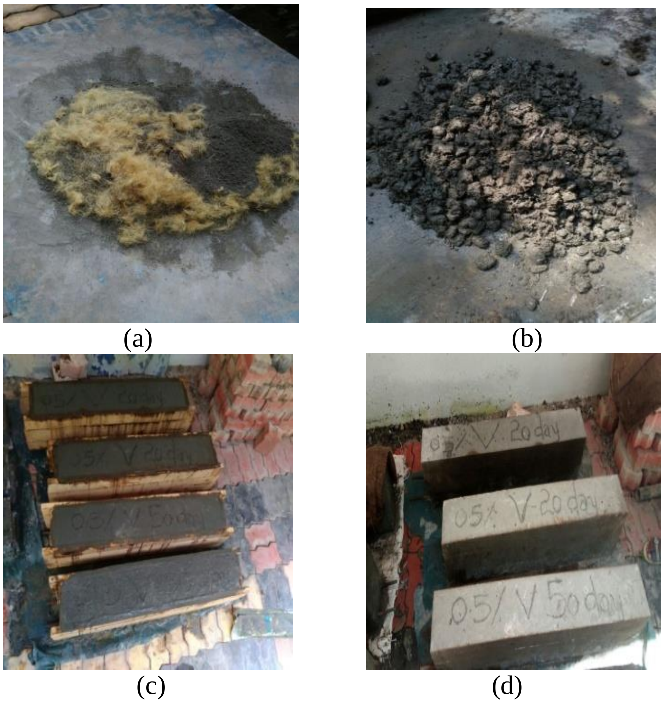

Fig- 2 : Casting procedures (a) Mixing of sisal fibre (b) Concrete mix (c) Casting of beams (d) Samples cast

4.6 Accelerated corrosion technique

After the curing of 28 days, the specimens were subjected to accelerated corrosion process to increase the corrosion rate in the rebars. The specimens were corroded using an electrochemical accelerated corrosion technique that involves applying a current of specified intensities through the specimens for a specified period to accelerate the oxidation process in a 5% sodium chloride (NaCl) solution. This was achieved through a small DC power supply to which the concrete specimens were partially immersed in 5% NaCl solution in a tank such that the base of the specimen was just in contact with water. The direction of the current was adjusted so that the reinforcing steel became an anode and a steel rod placed on the concrete specimen served as a cathode. The specimens were subjected to corrosion for 20 days and 50 days. The results of both the periods were studied.

Fig – 3: Accelerated corrosion technique set up

5. EXPERIMENTAL RESULTS

After the corrosion period the beam specimens with different percentages of sisal fibre (0%, 0.5%, 1% and 1.5%) were subjected to flexural strength test. Ultimate strength, deflection and crack width were noted. The results are as follows.

Table -2: Ultimate load values and crack width

Corrosion period	Ultimate load values with corresponding crack width				
20 Days	Percentage of fibre	0%	0.5%	1%	1.5%
	Ultimate load (kN)	160.5	160.8	150.8	112
	Crack width (mm)	25	10	15	30
50 Days	Ultimate load (kN)	118.1	120	38.7	38.6
	Crack width (mm)	28	21	20	31

From Table -2, it is clear that the concrete with 0.5%sisal fibre can take more loads compared to conventional concrete after same period of corrosion. The first crack in each specimen with different fibre content was obtained at different load values. The observations are given in Chart -1.

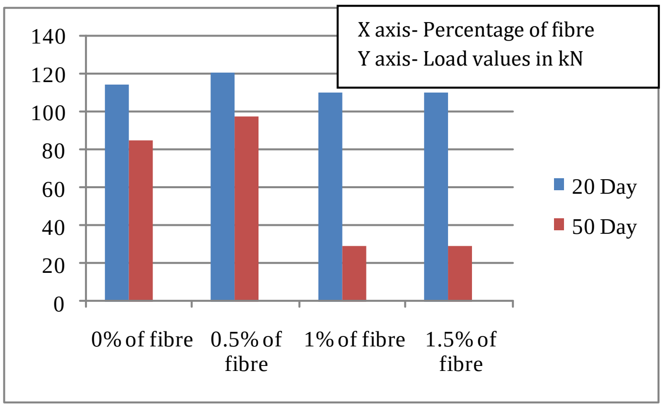

Chart - 1 : Load values at first crack

6. CONCLUSIONS

After completing the experimental evaluation on flexural strength and corrosion properties of RCC with sisal fibre, the following conclusions are drawn:

- By conducting the flexural strength test it is clear that the corrosion period influences the load carrying capacity of the reinforced concrete structures.
- Even after the loss of same amount of steel content by corrosion, the concrete with 0.5% sisal fibre shows a higher value of load carrying capacity as compared to the other percentages. At 20 day of corrosion a slight increment of 0.2% is found. But in the case of 50 day of corrosion the percentage of load carrying capacity is increased to 1.6%.
- With the addition of 0.5% fibre a delayed crack opening was observed in both 20 and 50 days of corrosion.
- By adding sisal fibre to the concrete the crack width reduces up to 1% as compared to the nominal concrete.

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