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Experimental Studies of Sisal Fibre in Portland Cement Concrete Elements on Durability

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ABSTRACT

Concrete prepared with Portland cement has certain character: it is comparatively strong in compression but weak in tension and tend to be breakable. The insufficiency in tension can be defeated by the make use of of conventional rod reinforcement and to some level by the enclosure of a sufficient volume of certain fibers. Change in the concert of the fiber-matrix composite after it has cracked, is due to the addition of fibers, thereby getting better in toughness. On account of its low density, a lesser amount of cost, improved specific strength and modulus, zero health risk, sisal fiber is a hopeful reinforcement for use in composites and it is easy procured in a number of countries. There has been an increasing importance in finding new application for sisal-fiber-reinforced composites that are conventionally used for making ropes fancy articles and others..The purpose of this study is based on the search of the use of sisal fibers in structural concrete to develop the mechanical characteristics of concrete. To find and compare the difference in properties of concrete contain no fibers and special concrete with fibers, as well as the association on the effects of dissimilar type and geometry of fibers to the concrete is the aim of the study. With the best results from the mix, resistance to chemical attack, bulk diffusion test abrasion resistance test are carry out.

KEYWORDS: Bulk diffusion, Durability, Fibre, Pseudo stem, Sisal hemp.

INTRODUCTION

Fiber is a natural or synthetic string. It is also used as a component of concrete, or when made into sheets. it is used to make products such as paper or felt. Fibers are often used in the manufacture of other materials. The strongest engineering materials often incorporate fibers. Fibers are a class of hair-like material that are continuous filaments or are in discrete elongated pieces, similar to pieces of thread. Concrete made with Portland cement has certain characteristics: it is relatively strong in compression but weak in tension and tends to be brittle. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers. The use of fibers also alters the behavior of the fiber-matrix composite after it has cracked, thereby improving its toughness. Since the advent of fiber reinforcing of concrete in the 1940`s, a great deal of testing has been conducted on the various fibrous materials to determine the characteristics and advantages for each product. Fibers produced by plants (vegetable, leaves and wood), animals and geological processes are known as natural fibers. Natural fibers possess the advantages like easy availability, light weight, Renewability of raw materials, low cost, high specific strength and stiffness.

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Natural fibers are cheap and locally available in many countries. Fibers are thread like materials which can be used for different purposes. The use of natural fibers reduces weight by 10% and lowers the energy needed for production by 80%, while the cost of the component is 5% lower than the comparable fiber glass-reinforced component

Sisal fiber:

Agave sisalana Perrine (Agavaceae), popularly known as sisal in is a monocotyledonous plant from Mexico. Sisal derives its name from a small port in the Yucatan peninsula of Mexico through which the earliest supplies of Agave fibers were exported and it became known to commerce as Sisal or 'sisal hemp'. The plants look like giant pineapples, and during harvest the leaves are cut as close to the ground as possible. Sisal represents the first natural fiber in commercial application, in which it is estimated in more than half of the total of all natural fibers used. The Sisal plant is a monocotyledonous, whose roots are fibrous, emerging from the base of pseudo stem.

Fig. 1: Sisal Fiber Plant

Sisal can be cultivated in most soil types except clay and has low tolerance to very moist and saline soil conditions. Husbandry is relatively simple as it is resilient to disease and its input requirement is low compared to other crops. These are mainly cultivated for fibers which are highly suited for ropes of all kinds Sisal fibers are extracted from an agave plant. Sisal fibers are stiff, straight, smooth and yellow in color. Strength, durability and ability to stretch are some of the important properties of sisal fibers. Sisal fiber is one of the most widely used natural fibers and it can be easily harvested. Sisal plant produces over 200-250 leaves during its life time of 7 to 8 years and each leaf contains 1000-1200 fiber bundles. Sisal leaf contains three types of fibers. They are mechanical, ribbon and xylem fibers. Mechanical fibers have a roughly thickened horseshoe shape and hardly divide during extraction process. It is present in the periphery of the leaf. Ribbon fiber occurs in association with the conduction. Xylem fibers have an irregular shape and occur opposite to ribbon fibers through the connection o vascular bundles.

Table 1: Chemical composition of sisal fiber

CHEMICALS	PERCENTAGE
Cellulose	71.5%
Hemicelluloses	18.1%
Lignin	5.1%
Pectin	2.3%
Waxes	0.5%
Total	100%

II. Methodology:

Concept of using sisal fiber in concrete was conceived. Based on the concept, various journals where referred and an idea about the natural fiber known as the sisal fiber being used in concrete was obtained. The knowledge on fiber reinforced concrete was also obtained by referring various journals. Literature review was done and the concept was finalized various tests on Cement, fine aggregate and coarse aggregates were carried out and the results were obtained. In order to do find the merit or demerit of any special concrete, it has to be compared with conventional concrete. Therefore, a set of conventional concrete specimen is required. In order to cast a set of conventional concrete, initially the mix design forM20, M30, M40 grade of concrete has to be done. Tests on fresh concrete were carried out. Workability was checked by carrying out slump test. The water cement ratio and the percentage of super plasticizer to be added was also determined based on three different designs of trail mix. The mixes with optimum results were considered for casting conventional concrete. The same mix ratio which was used to cast conventional concrete specimen, was used to cast special concrete specimens. Special concrete specimens are fiber reinforced specimens. Four different aspect ratios are considered. Fiber was cut for each aspect ratio. For each aspect ratio, four different percentage of amount of fiber were added to concrete mix. Special concrete specimens consist of cubes, cylinders and beams. OPC grade 53 cement was used in casting. The coarse aggregate added to the mix was divided into two portions. 60% of 20mm aggregate and 40% of 12.5mm aggregate was used. 16 mixes of special concrete specimens were cast and cured. 3rd , 7th and 28th day testing were carried out to find the compressive strength, split tensile strength and flexural strength for the special concrete. With the results obtained, the optimum result was found. With the optimum result, the aspect ratio and the percentage which gives us the optimum result is found. With this aspect ratio and percentage, the research to carryout durability tests.

III. Test for durability:

The durability kind incorporated the microstructure associated properties such as resistance to chemical attack, bulk diffusion test abrasion resistance test are carry out.

3.1. Resistance to chemical attack:

The resistance to chemical attack of test specimen be assessed by conduct acid resistance examination and sulphate resistance test. After 28 days of cast the 100 mm dice specimen were oven dried at 100 _C for 24 h and weigh. Out of the nine cube specimen of every mix, three were measured as control specimen for sentence the loss in compressive strength. Three specimens from every mix were immersed in 3% sulphuric acid (H_2SO_4) solution for 180 days and the lasting three were immersed in 3% sodium sulphate solution following noting their initial weights. The solutions were reserved at laboratory ambient state and were disturbed every day to continue uniformity and were misshapen every month. After 180 days the specimen were occupied out and their dry weights were famous. Their visual appearance, loss in weight and compressive strengths were then examined. The ocular appearance of the specimens behind soaking in 3% of sulphuric acid solution for 6 months given away that there was not a great deal change in appearance for special specimen. But CC specimen exposed to H_2SO_4 solution had undergone face erosion. Because of the decalcification of C–S–H gel, the CC surface became soft and got disconnected thus revealing the interior layers to corrosion. Since the calcium contented in the fly ash used was very low for the fiber specimen exposed to H_2SO_4, the formation of calcium sulphate was lesser in extent which made it extra resistant to H_2SO_4. The results of acid struggle test are shown in Table 2. most weight loss suffered by fiber concrete was 1.5% whereas for CC it was 2.14%. The highest loss in compressive strength of fiber specimens was only 20% and for CC it was 19%. The ocular look of the test specimen after sopping in 3% sodium sulphate solution for 6 months given away that there was no change in the manifestation of the specimen match up to to the circumstance before they were exposed. There was no signal of surface erosion, cracking or spelling. The results of sulphate assault test are shown in Table 3. From the table it can be seen that plain and thread reinforced NC and CC specimens bear unimportant weight loss. It can also be see that the loss in compressive force of plain and fibre concrete specimen was a smaller amount than 20%, but for CC specimen it was approximately 14%.

Table 2: Results of acid resistance and sulphate resistance test. (Conventional)

Mix	Acid attack		Sulphate attack	
	% weight loss	% loss in compressive strength	% weight loss	% loss in compressive strength
M20	1.80 19.95		0.24 12.52	
M30	2.10 19.90		0.29 12.95	
M40	2.14 19.82		0.28 13.10	

Table 3: Results of acid resistance and sulphate resistance test :(special concrete)

Mix	Acid attack		Sulphate attack	
	% weight loss	% loss in compressive strength	% weight loss	% loss in compressive strength
M20	1.86 21.15		0.44 13.42	
M30	2.18 21.50		0.49 13.75	
M40	2.19 21.32		0.38 14.20	

3.2. Bulk diffusion test:

In this analysis the evident chloride diffusion coefficient of hardened cementations equipment is resolute. ASTM C 1556 provides a system for result the evident chloride distribution Coefficient, which is the controlling parameter for chloride ion migration in saturated pore system. Cylindrical sample of 100 mm distance and 200 mm elevation were old for the test. The specimen after 28 days of medicinal were kept immersed in 3.5% sodium chloride resolution (NaCl) for 35 days. The specimen was then crack by loading in a compression trying machine alike to split tensile examination. The split surface was sprayed with 0.1 M AgNo3 (silver nitrate) solution to determine the depth of salt saturation by distinction in colour of portion of concrete with and lacking the company of chloride ions. A white rain was formed up to the penetrate depth. From the strength of chloride dispersion, the diffusion coefficient can be considered by Eq. as given in .

$X_d = 4\sqrt{Dt}$

Where,

Xd= depth of chloride penetration in cm.

D= diffusion coefficient.

t = duration of exposure (35 days).

The value of diffusion coefficient for all the specimen be premeditated and are given in Table 4. The test grades given missing that chloride diffusion coefficient of in cooperation fiber concrete and CC were comparable.

Table 4: Results of Bulk Diffusion Test :(conventional)

Mix	Depth of chloride penetration (cm)	Diffusion Coefficient (m2/s)	Charge Passed (C)	passed Chloride ion penetrability as per ASTM
M20	2.43	$1.23x10^{-11}$	1318	Low
M30	2.40	$1.20x10^{-11}$	1440	Low
M40	2.38	$1.16x10^{-11}$	1389	Low

Table 5: Results of Bulk Diffusion Test :(special concrete)

Mix	Depth of chloride penetration (cm)	Diffusion Coefficient (m2/s)	Charge Passed (C)	passed Chloride ion penetrability as per ASTM
M20	2.49	$1.28x10^{-11}$	1328	Low
M30	2.47	$1.26x10^{-11}$	1451	Low
M40	2.46	$1.22x10^{-11}$	1402	Low

3.3. Abrasion resistance test:

Abrasion resistance of concrete can be defined as its capacity to oppose being shabby away by rubbing. Cube samples of face area 50 cm2 and width 2.5 cm were worn for the test according to IS 1237. The abrasion system consists of a steel disc have a thickness of 750 mm and rotating at a pace of 30 ± 1 cycle/min, a oppose and a lever which could be appropriate a load of 300 ± 3 N on the specimens. Abrasive dust (corundum aluminium Oxide Al2O3) of 20 ± 0.5 g was first multiply in excess of the disc. The specimens were then located in the holding mechanism and the load was functional to the specimen and the disc be rotated for four stage and each period was alike to 22 cycles. After that, the face of the disc and the sample were clean and 20 g fresh corundum powder was extra and the method was repeated for 20 period (total 440 cycles) by rotary the sample 90_ in every period. Weight of the specimens after 440 cycles of revolt was occupied and the percentage loss in weight was premeditated. Loss in width which is a measure of wear (t) of the specimens was designed by Equation. Table 6 show the percentage weight loss and average bear of all the tested specimen

$t = ((w'-w_1')/(w'*A))*V$

W’ = initial weight of the sample, W'_1 = final weight of the sample. V = initial volume of the sample, A = surface area of sample. As per IS 1237, the wear shall not go above 3.5 mm for general function of core tile and shall not surpass 2 mm for important duty cube sample. The normal wear of all the specimen was set up to be in the limit. Compared to CC specimen perform well in scratch and the average wear suffered by sisal fiber concrete be 27% less than that of CC; also fibre adding improved the abrasion resistance of both NC and CC. The reason for this may be suitable to the increased thickness of fiber specimens as explain in the preceding part.

Table 6: Results of abrasion resistance test.(conventional)

Mix	Initial weight (kg)	Final weight (kg)	% weight loss	Average wear in mm	% reduction in wear with respect to CC
M20	0.83	0.82	0.21	0.15	25.30
M30	0.86	0.85	0.15	0.06	60.23
M40	0.81	0.79	0.05	0.05	61.59

Table 7: Results of abrasion resistance test :(special Concrete)

Mix	Initial weight (kg)	Final weight (kg)	% weight loss	Average wear in mm	% reduction in wear with respect to CC
M20	0.94	0.93	0.31	0.213	29.54
M30	0.98	0.96	0.23	0.113	63.32
M40	0.94	0.93	0.22	0.123	65.22

Conclusions:

Durability description of plain and fibre resistant concrete and conformist concrete were assess in terms of water absorption, porosity, sorptivity, abrasion resistance, resistance to chemical attack, resistance to alternate wetting and drying and chloride ion penetrability. From the test grades, the following conclusions were drained. Abrasion resistance of fiber specimens be originate to be upper than those of CC. The normal wears of fiber specimen were 27.5% fewer than that of CC specimen. The standard wear of nominal specimen was approximately 65% fewer than that of CC specimen. Chloride diffusion coefficient of together fiber and CC was almost alike. fiber specimen show brilliant resistance to acid and sulphate attack and suffered less than 2% weight loss when uncovered to 3% H_2SO_4 solution for 6 months. equivalent weight loss for CC specimen was 27%. Both fiber specimen and CC specimen suffer fewer than 1% weight defeat when subjected to sulphate bother The loss in mass and compressive strength of both fiber concrete and CC sample were less than 5% and 20% in that order when subjected to interchange wetting and drying conditions in marine atmosphere Chloride ion penetrability of both fiber concrete and CC is roughly alike.

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