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RESEARCH ARTICLE

" Use of horse hair as fiber reinforcement in concrete"

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Abstract

Fiber reinforced concrete can offer a convenient, practical and economical method for overcome micro-cracks and similar type of deficiencies. Since concrete is weak in tension hence some measures must be adopted to overcome this deficiency. Horse hair has less tensile strength than human hair. It can be used as a fiber reinforcement material and has a main advantage that it is heat resistant. Horse-Hair Fiber (HHF) an alternate non-degradable matter is available in abundance and at a very cheap cost. It also creates environmental problem for its decompositions. Present studies has been undertaken to study the effect of horse hair on plain cement concrete on the basis of its compressive, crushing, flexural strength, cracking control and heat resistant to economize concrete and to reduce environmental problems. Experiments were conducted on concrete beams and cubes with various percentages of horse hair fiber i.e. 0%, 1%,and 2%,by weight of cement. For each combination of proportions of concrete one beam and three cubes are tested for their mechanical properties. By testing of cubes and beams we found that there is an increment in the various properties and strength of concrete by the addition of horse hair as fiber reinforcement and were tested for heat resistance.

INTRODUCTION

Almost everybody has heard about the concrete and knows that it is something which is used in construction of structures. And also very few of us have heard about the fiber reinforced concrete. But, what exactly the fiber reinforced concreteis?

The concept of using horse hair as fiber reinforcement and heat resistant material in concrete is not new. Fibers have been used as reinforcement since ancient times. Historically, horse-hair was used in mortar and straw in mud bricks etc.

Fiber Reinforced Concrete (FRC) can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers. Continuous meshes, woven fabrics and long wires or rods are not considered to be discrete fibers. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers.

Fiber is a small piece of reinforcing material possessing certain characteristics properties. The fiber is often described by a convenient parameter called aspect ratio. The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

Advantages of horse hair as fiber reinforced concrete

Fiber Reinforced Concrete (FRC) has started finding its place in many areas of building infrastructure applications especially where the need for repairing, increased durability arises and in the areas where temperature exceeds more than 40°C. FRC is used in building structures where corrosion is to be avoided at the maximum. FRC is better suited to minimize cavitations /erosion damage in structures such as sluice-ways, navigational locks and bridge piers where high velocity flows are encountered. A substantial weight saving can be realized using relatively thin FRC sections having the equivalent strength of thicker plain concrete sections. When used in bridges it helps to avoid catastrophic failures. In the quake prone areas the use of fiber reinforced concrete would certainly minimize the human casualties.

Fibers reduce internal forces by blocking microscopic cracks formation within the concrete.

Disadvantages of horse hair fiber reinforced concrete

The main disadvantage associated with the fiber reinforced concrete is fabrication. The process of incorporating horse-hair fiber into the cement matrix is labour-intensive and costlier than the production of the plain concrete. The real advantages gained by the use of Horse-Hair FRC overcome this disadvantage.

Why Fibers are used in Concrete?

Fibers are usually used in concrete for the following reasons:

i. To control cracking due to both plastic shrinkage and drying shrinkage.

ii. They also reduce the permeability of concrete and thus reduce flow of water through it.

iii. Some types of fibers also produce greater impact, abrasion and shatter resistance in concrete.

iv. The fineness of the fibers allows them to reinforce the mortar fraction of the concrete, delaying crack formation and propagation. This fineness also inhibits flow in the concrete, thereby reducing permeability and improving the surface characteristics of the hardened surface.

v. To protect it from the affects of the temperature, thereby keeping concrete at optimum temperature which reduces cracks and fissures.

Main Properties of Horse-Hair Fiber in FRC

i. Volume percentage of horse-hair fiber (0.1 to 4%).

ii. Aspect ratio (the length of a fiber divided by its diameter).

iii. Orientation and distribution of the fibers in the matrix.

iv. Spilling free concrete.

v. Shape, strength, dimension and length of fiber is important.

Why Horse Hair as a Fiber?

Horse-Hair is used as a fiber reinforcing material in concrete for the following reasons:

i. It has high tensile strength, which is equal to that of a copper wire with same diameter.

ii. Hair, a non-degradable matter is creating environmental problems, so its use as a fiber reinforcing material can minimize such problems.

iii. It is also available in abundance and at a very low cost.

iv. It reinforces the mortar and prevents it from spilling.

Methodology

The methodology adopted to test the mechanical properties and strength of horse-hair reinforced concrete is governed by Compressive Strength and Flexural Strength.

Various cubes and beams are tested and analyzed for finding the effect of using horse-hair as fiber reinforcement.

Tests Performedfor determining the effect of horse-hair as fiber in concrete.

Compression Strength test

It is the most common test conducted on hardened concrete as it is an easy test to perform and also most of the desirable characteristic properties of concrete and qualitatively related to its compressive strength. The compression test is carried out on specimens cubical in shape of size 150 × 150 × 150 mm.

The test is carried out in the following way. First of all the mould preferably of cast iron, is used to prepare the specimen of size 150 × 150 × 150 mm. During the placing of concrete in the moulds it is compacted with the tamping bar with not less than 35 strokes per layer. Then these moulds are placed on the vibrating table and are compacted until the specified condition is attained. After 24 hours the specimens are removed from the moulds and immediately submerged in clean fresh water. After 28 days the specimens are tested under the load in a compression testing machine.

Flexural Strength test

Direct measurement of the tensile strength of concrete is difficult. Neither specimens nor testing apparatus have been designed which assure uniform distribution of the pull applied to the concrete. The value of the extreme fiber stress in bending depends on the dimensions of the beam and manner of loading. In this method the critical crack may appear at any section, not strong enough to resist the stress within the middle third, where the bending is maximum. The test is carried out in the following way. First of all the mould preferably of cast iron, is used to prepare the specimen of size 150 × 150 × 700 mm. During the placing of concrete in the mould it is compacted with the tamping bar weighing 2 kg, 400 mm long with not less than 35 strokes per layer. Then this mould is placed on the vibrating table and is compacted until the specified condition is attained. After 24 hours the specimen is removed from the mould and immediately submerged in clean fresh water. After 28 days the specimen is taken out from the curing tank and placed on the rollers of the flexural testing machine for testing. Then the load is applied at a constant rate of 400 kg/min. The load is applied until the specimen fails, and the maximum load applied to the specimen during the test is recorded.

The specimen for both the test is made in the following manner:

i.For Compression test: Three cubes are made for each M-15, M-2O and M-25 with 0%, 1%, and2% hair by weight of cement.

ii. For Flexural Strength test: One beam is made for each M-15, M-2O and M-25 with 0%, 1%,and 2%,hair by weight of cement.

Analysis of Data collected

i. Compression test: The results from the compression test are in the form of the maximum load the cube can carry before it ultimately fails. The compressive stress can be found by dividing the maximum load by the area normal to it. The results of compression test and the corresponding compressive stress is shown in Table 1.

Let, P = maximum load carried by the cube before the failure

A = area normal to the load = 150 × 150 mm^2 = 22500 mm^2

σ = maximum compressive stress (N/mm^2).

Therefore,$\boldsymbol{\sigma = P/A}$

ii. Flexural Strength test: - The results from the flexural strength test are in the form of the maximum load due to which a beam fails under bending compression. The results of flexural strength test and its corresponding bending stress is shown in Table 2.

Let M = Moment of Resistance,

I = Moment of Inertia about neutral axis,

σ_b = Bending stress,

y = Extreme fiber distance from neutral axis,

W = Maximum load at which beam fails,

b = width of the beam, d = depth of the beam

Then $\boldsymbol{\sigma_b = 3Wl \div 4bd^2}$

Table 1: Results obtained from compression test and corresponding compressive stress.

S No.	Mix	% horse hair	Maximum load (KN)			Compressive stress (N/mm^2)		
			Cube 1	Cube 2	Cube 3	Cube 1	Cube 2	Cube3
01	M-15	0.00	352.5	349.8	371.2	12.11	11.99	12.94
02	M-20	0.00	475.7	482.4	497.4	17.57	17.88	18.55
03	M-25	0.00	557.5	556.3	560.0	21.24	21.17	21.33
04	M-15	1.00	405.5	439.5	341.3	14.48	15.99	11.61
05	M-20	1.00	413.4	496.7	524.0	14.81	18.52	19.73
06	M-25	1.00	591.3	589.1	571.8	22.72	22.64	21.85
07	M-15	2.00	430.5	438.1	449.8	15.58	15.92	16.43

08	M-20	2.00	530.8	505.8	549.1	20.01	18.92	20.85
09	M-25	2.00	613.7	642.2	607.8	23.72	26.98	23.45

Table 2: Results obtained from flexural strength test and corresponding bending strength.

S no.	**Mix**	**% horse hair**	**Maximum load (KN)**	**Bending Stress (N/mm^2)**
01	M-15	0.00	35.30	3.14
02	M-20	0.00	42.90	3.81
03	M-25	0.00	46.00	4.09
04	M-15	1.00	36.50	3.24
05	M-20	1.00	44.00	3.91
06	M-25	1.00	47.30	4.21
07	M-15	2.00	38.40	3.41
08	M-20	2.00	45.20	4.02
09	M-25	2.00	48.00	4.26

Conclusion

According to the test performed it is observed that there is remarkable increment in properties of concrete according to the percentages of horse hairs by weight in concrete. When M15 concrete with 1% hair is compared with the plain cement concrete, it is found that there is an increase of 8% in compressive strength and 3% in flexural strength. When M-15 concrete with 2% hair is compared with the plain cement concrete, it is found that there is an increase of 20% in compressive strength and 8.2% in flexural strength. When M-20 concrete with 1% hair is compared with the plain cement concrete, it is found that there is no increase in compressive strength and 1% in flexural strength. When M20 concrete with 2% hair is compared with the plain cement concrete, it is found that there is an increase of 8.4% in compressive strength and 5.1% in flexural strength. When M-25 concrete with 1% hair is compared with the plain cement concrete, it is found that there is an increase of 4.6% in compressive strength and 3% in flexural strength. When M-25 concrete with 2% hair is compared with the plain cement concrete, it is found that there is an increase of 11% in compressive strength and 4% in flexural strength.

Problems Encountered

It is well said that: “The taste of defeat has a richness of experience all its own.” During our research work we also faced the problem of uniform distribution of hair in the concrete. So to overcome this problem we have adopted the manual method of distribution of hair in the concrete.

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