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Experimental Study on Use of Human Hair & Jute As A Fiber Material In Concrete

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ABSTRACT

This research investigates the synergistic effect of incorporating two natural fibers—human hair (HH) and jute fiber (JF)—as strengthening agents in concrete, aiming to enhance mechanical properties while promoting sustainable waste management. Due to its high tensile strength (comparable to copper wire) and non-biodegradable nature, human hair is utilized to enhance bonding and crack control. Similarly, jute fiber is an affordable, abundant natural material that increases ductility and reduces shrinkage.

The study involved experimental investigations on concrete cubes, cylinders, and beams using varying percentages of human hair (0–3%) and jute fibers (0–1%) by weight of cement, with standard curing periods. Test results showed that the optimum inclusion of human hair (approximately 1.5–2%) significantly improved compressive strength (up to 12% increase) and split tensile strength (up to 20% increase). The addition of jute fiber, optimal at roughly 0.5%, showed a significant increase in tensile and shear strength, while also enhancing ductile behavior, reducing brittle failure.

Microstructural improvements include increased crack resistance, better binding, and decreased spalling. However, high percentages of either fiber can reduce workability and cause fiber balling, lowering strength. The study concludes that the hybrid use of human hair and jute fiber acts as an eco-friendly and cost-effective method to improve concrete performance, suitable for applications in seismic-resistant, low-cost housing, and non-structural components.

Introduction

General:

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.

Fiber Reinforced Concrete (FRC) was invented by French gardener Joseph Monier in 1849 and patented in 1867. The concept of using fibers as reinforcement is not new. This can be proved by the following fibers have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. In the early 1900s, asbestos fibers were used in concrete, and in the 1950s the concept of composite materials came into being and fiber reinforced concrete was one of the topics of interest. There was a need to find a replacement for the asbestos used in concrete and other building material once the health risks associated with the substance were discovered. By the 1960s, steel, glass (GFRC), and synthetic fibers such as polypropylene fibers were used in concrete, and research into new fiber reinforced concretes continues today.

The use of fibers widely started in developed industrial countries in early 1960s and during these fifth decades the quality of fibers and the way of making fiber concrete has improved and its use also increased. Historical evidence of this technology is the use of thatch in the building. After the concrete was cured and dried, due to hydration and moisture reduction, also tensile stresses reduction in the concrete surface happens, causing shallow cracks in concrete. If one does not pay attention to these cracks that extend by shrinkage they create channels for passing of external destructive element and reduce concrete durability in long term. According to the review of technical literature, there were generally four main types of shrinkage listed in the sources. Shrinkage of hardened concrete caused by loss of water in concrete before or shortly after the formation of concrete. Shrinkage resulted in form the carbonate, because of the chemical reaction of cement hydration products with carbon dioxide in the air is created and is limited to the concrete surface with low permeability. Spontaneous shrinkage occurred in concrete during hydration due to chemical reaction and loses of water.

1.1 Types of Fibers:

1. Steel Fiber
2. Glass Fiber
3. Synthetic Fiber
4. Carbon Fiber
5. Coconut Fiber
6. Banana Fiber
7. Natural Fiber (Hair)
8. Jute Fiber

Natural Fiber (Hair)

Historically, fiber-reinforced concrete has used natural fibers, such as hay or hair. While these fibers enhance the strength of concrete they can also make it weaker if too much is used. In addition, if the natural fibers are rotting while being mixed, then the rot can continue even while in the concrete.

This eventually leads to the concrete crumbling from the inside which is why natural fibers are no longer used in construction. Natural fiber use because hair are not decomposition & not absorbed the water.

Jute Fiber:

Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. It is produced primarily from plants in the genus Co chorus, which was once classified with the family Tiliaceae, and more recently with Malvaceae. The primary source of the fiber is Co chorus olitorius, but it is considered inferior to Co chorus capsular is."Jute" is the name of the plant or fiber that is used to make burlap, hessian or gunny cloth.

Literature Review

2.1 History:

Yadollah Batebi et. al, (2013). Observed that use of fiber in concrete is a new idea in this case according to him, there were some evidences that horse hair, straw and cotton fibers were used in mud and mortars in ancient times. Then, utilizing these fibers in concrete mixture may increases concrete workability and decrease shrinkage cracks. Due to nano cross-section of hair and its proper tensile strength this project investigation its application to reduce the shrinkage of concrete mixtures. For this purpose, human hair fibers were used in 0.4 and 0.8 and 1.2 weight percent and the length of the fibers in each case varied between 15 and 60 mm and the samples were made of dimension of 40×40×160 mm. results are shown as considerable amount of hair may reduce in the shrinkage in the hair reinforced concrete. At last, he concluded an effective way for controlling cracking caused by pasty condensation is to reinforce concrete by fibers.

Kothari A et. al, (2012). Observed that concrete is weak in tension hence some measures must be adopted to overcome this deficiency. According to him, human hair is strong in tension; hence it can be used as a fiber reinforcement material. Hair fiber an environmental problem for its decompositions. Present studies has been undertaken to study the effect of human hair on plain economies concrete and to reduce environmental problems. At last, he concluded testing of cubes and beams we found that there is an incremental in the various properties and strength of concrete by the addition of human hair as fiber reinforcement.

Shih-Ho Chao et. al, (1999). Observed that bond between deformed reinforcing bars and concrete induces significant tensile stresses that lead to cracking in concrete due to its weak and brittle nature in tension. According to him, contrary to plain concrete and conventional fiber-reinforced concrete, high-performance fiber-reinforcing cement composites show strain hardening response under tension and thus their use can lead to enhanced bond performance. At last, he concluded effect provide by fibers in FRC composites after cracking can effectively provide post-cracking tensile capacity to the concrete matrix and limit crack width, thereby leading to enhanced bond resistance. HPFRCC specimens give the best bond performance in term of bond strength and stiffness retention capacity, as well as damage-control ability.

1.2 Natural Fiber Human Hair:

Fiber is usually used in concrete for the following reasons:

1. To control cracking due to both plastics shrinkage and drying shrinkage.
2. They also reduce the permeability of concrete and thus reduce bleeding of water.
3. Some types of fiber also produce greater impact, abrasion and shatter resistance in concrete.
4. The fineness of the fibers allows them to fineness also inhibits bleeding in the concrete, thereby reducing permeability and improving the surface characteristics of the hardened surface.

1.3 **Natural Fiber Jute:**

a) Jute has high specific properties, low density, less abrasive behavior.

b) Jute textile is a low cost eco-friendly product and is abundantly available.

c) It is easily transport and has superior drivability and moisture retention capacity.

d) It is widely being used as a natural choice for plant mulching and rural road pavement construction.

e) The biodegradable and low priced jute products merge with the soil after using providing nourishment to the soil.

Properties of Fiber-Reinforced Concrete

3.1 Fiber-Reinforced concrete:

Types of fibers used volume percent of fiber (vf = 0.1 to 3%), aspect ratio (the length of a fiber divided by its diameter), orientation and distribution of the fibers in matrix, it prevents spalling of concrete, shape dimension and length of fiber is important, strength of the fiber.

Fiber reinforced concrete 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 roads are not considered to be discrete 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.

Hairs are used as a fiber reinforcing material in concrete to study its effect on the compressive crushing, flexural strength and cracking control to economies concrete and to reduce environmental problems created by the decomposition of hair.

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

1. It has a high tensile strength which is equal to that of a copper wire similar diameter.
2. Hair, a non-degradable matter is creating an environmental problem so its use as a fiber reinforcing material can minimize the problem.
3. It is also available in abundance and at a very low cost.
4. It reinforces the mortar and prevents it from spalling.

3.2 Disadvantages of fiber reinforced concrete:

The main disadvantages associated with the fiber reinforced concrete are fabrication. The process of incorporating fibers into the cement matrix is laboured intensive and costlier than the production of the plain concrete. The real advantage gained by the use of FRC overrides this disadvantage.

3.3 Material and Methods:

3.3.1 Materials:

In most of construction projects, ordinary Portland cement with standard specification stated with ultra tech grade 52 cement and fine granulated sand standard with softness factor of 2.76 water absorption of 2.8 percent and specific weight 2.71 percent and maximum size sand aggregate of

2.36 mm were used. Water used in this project for making curing concrete and growing samples is drinkable water. Also two different lengths of hair fibers 15 and 60 mm length 0.05-0.10 mm diameter were used. The characteristics of hair are discussed in following section and the reason of its usage as an amplifier in mortar is expressed.

3.3.2 Hair:

The main element of hair composition is keratin. Keratins are proteins with long chains of amino acids that form the cytoskeleton of all cells of outer shell. Number of investigations clearly stated that sulfur is the main reason of strength of hair cords in front of disintegration in the face of environmental stress and these sulfur compounds are linked with amino acids at very high levels in hair cords.

Sulfur in amino acid molecules is adjacent to keratin protein till form disulfide chemical chains. These chains are very resistance to acid disulfide performance, but in alkaline solution they can decomposed. In fact alkaline environmental looses the hair cords. The potential impact of reduces strength in the cement mortar of hair is still a noteworthy but we have to mention that the purpose of this article is to investigation the impact of hair cord in control of shrinkage and cracks which are caused in normal concrete. Before the alkaline environment loose the hair cords, these cords may respond on purpose to their functions to prevent shrinkage. The details image of the external surface of a human hair that has been studied with electron microscope. Hairs diameter are 0.050 to 0.10 mm and bumps on it are in nano size. These bumps help to lock cement mortar with hair cords. Size number of these bumps is variable depending on hair type.

3.3.3 Jute:

India is one the large jute producing country. Jute is an important bastfiber with a number of advantages. Jute has high specific properties, low density, less abrasive behavior to the processing equipment, good dimensional stability and harml essness. Jute textile is a low cost eco- friendly product and is abundantly available, easy to transport and has superior drapability and moisture retention capacity. It is widely being used as a natural choice for plant mulching and rural road pavement construction. The biodegradable and low priced jute products merge with the soil after using providing nourishment to the soil. Being made of cellulose, on combustion, jute does not generate toxic gases.

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Methodology

4.1 Characteristics of Mortar Mixture:

This research includes 36 mortar mixing samples with 0, 1%, 2% from hair and jute fibers in two different length of 15 and 60 mm. in all samples the ratio of water to cement is 0.50 and amount of granular stone is stable and equals 1835 kg/m^3 and cement grade is 3150 kg/m^3. The ratio of mixed samples is summarized. Tests were carried by different length of hair and jute 160 mm length and 40 mm width and depth (since the aim of these experimental was to compare degree of condensation, dimension of samples had no significant effect on final result). Based on standard, condensation caused by drying in mortar has liner relation with condensation caused by drying in research sand-cement mortars are used for comparing degree of condensation, weight percent of 0, 1, 2% hair and jute fibers in two medium length 15 and 60 mm for each weight percent were used. The selection of these length is based on available hair length and the size and dimension of fibers. Test included five control concrete and three sample concrete for each mixture with different weight percent and hair and jute length.

Generally, it was considered and made 36 samples for implementation of the test the sample hair and jute used in preparation of concrete samples with hair fibers. For preparation of samples we used pure cement and sand with identified weight in a dish and mix it by hand about 2 or 3 minutes. Then we add required amount of water in 2 steps and mixture obtained compound in required amount. In this step, control concrete was modeled. In the next step, waste hair based on percentage was added. The mixture was vibrated for uniform sample. After molding, it was covered molds by nylon for reserving against wet changes. After 24 hours processing in wet situations, the samples were exited from steel frames.

4.2 Measurement Tools:

The primarily measurement was carried out by a meter for each sample. According to calibration stage, it was stick the measuring scales device on each sample in 10 cm distance from each other. Samples were put on one table so it was not important changes of length and in order fixing temperature and wetness they were covered by a plastic film. The changes in length of sample on 7^{th}, 14^{th} day were determined.

4.3 Test Performed:

1. Compression Test

Various cubes tested and analysis for finding the effect of using hair and jute as fiber reinforcement. We are going to do the test performed in that one test are important that is compressive test.

4.3.1 Compression Test:

Compression test that test is the most common test conducted on hardened concrete as it is an easy test to perform and also most of the desirable characteristics properties of concrete are qualitatively related to its compressive strength. The compression test is carries out on specimens cubical in shape of the size 150×150×150 mm. The test is carried out in the following steps, 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.

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 7 days, 14 days the specimens are tested under the loads in a compression testing machine.

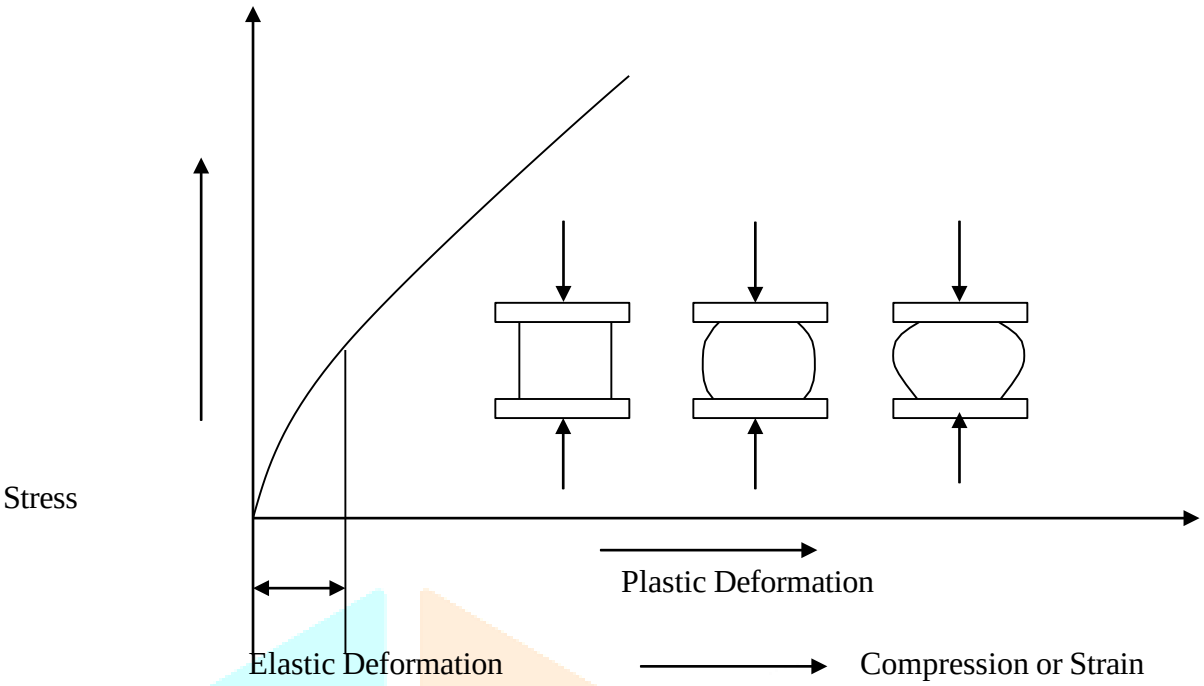
Two cubes are made for each M-20 and M-25 with 0%, 1% and 2% hair and Jute by weight of cement.

The results from the compression test are in the form of the maximum load the cube can carry before it ultimately fails. The compression stress can be found by dividing the maximum load by the areas normal to it. The results of compression test and the corresponding compressive stress by the help of CTM.

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)

$$\sigma = \frac{P}{A}$$



Loading Patter on Cube Figure 4.1

Result

Result For M-20 Grade Concrete Cubes: -

Sr. No.	Concrete Grade	% Jute	Max. Load Recorded (KN)		Compressive Stress (N/mm^2)		Compressive Stress (N/mm^2)
			7 Days	14 Days	7 Days	14 Days	Average
1.	M-20	0%	410	430	18.22	19.11	18.66
2.	M-20	1%	430	460	19.11	20.44	19.77
3.	M-20	2%	480	520	21.33	23.11	22.22

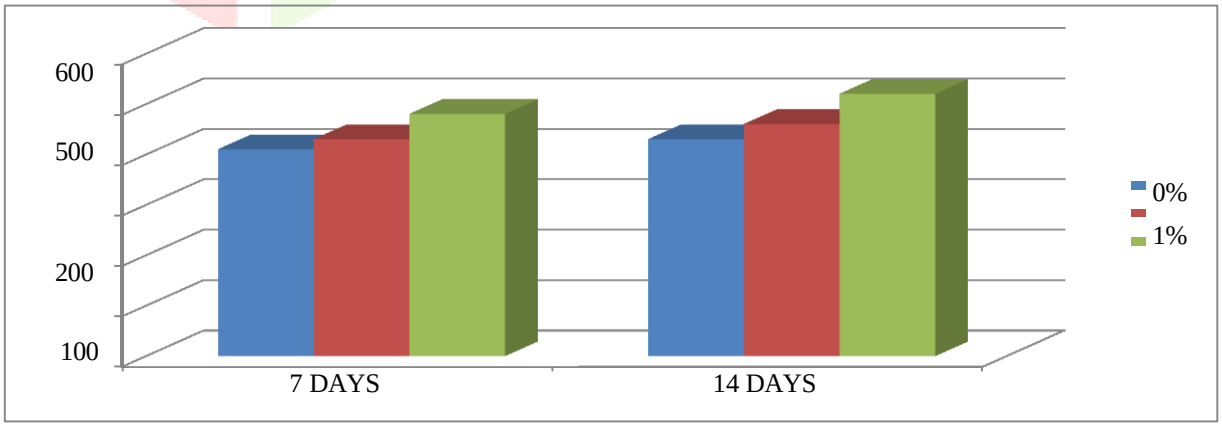


Chart 5.1

Result For M-25 Grade Concrete Cubes:-

Sr. No.	Concrete Grade	% Jute	Max. Load Recorded (KN)		Compressive Stress (N/mm^2)		Compressive Stress (N/mm^2)
			7 Days	14 Days	7 Days	14 Days	Average
1.	M-25	0%	540	550	24	24.44	24.22
2.	M-25	1%	570	585	25.33	26	25.66
3.	M-25	2%	600	615	26.67	27.33	27

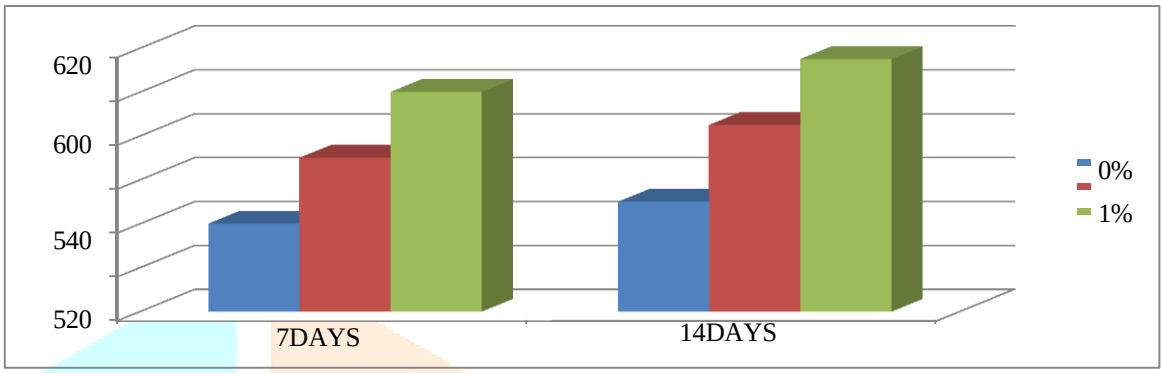


Chart 5.2

Result For M-20 Grade Concrete Cubes:-

Sr. No.	Concrete Grade	% Hair	Max. Load Recorded (KN)		Compressive Stress (N/mm^2)		Compressive Stress (N/mm^2)
			7 Days	14 Days	7 Days	14 Days	Average
1.	M-20	0%	410	430	18.22	19.11	18.66
2.	M-20	1%	450	490	20	21.77	20.88
3.	M-20	2%	520	530	23.11	23.56	23.33

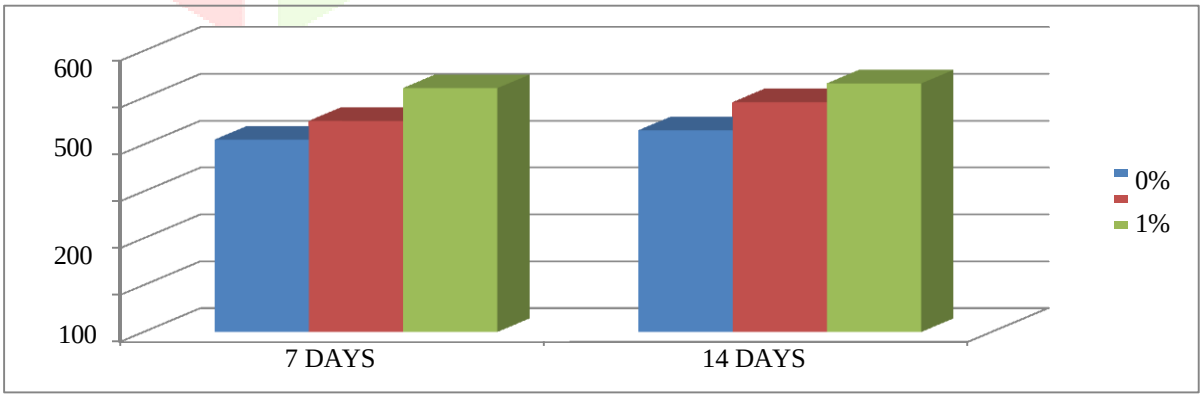


Chart 5.3

Result For M-25 Grade Concrete Cubes:-

Sr. No.	Concrete Grade	% Hair	Max. Load Recorded (KN)		Compressive Stress (N/mm^2)		Compressive Stress (N/mm^2)
			7 Days	14 Days	7 Days	14 Days	Average
1.	M-25	0%	540	550	24	24.44	24.22
2.	M-25	1%	590	600	26.22	26.67	26.44
3.	M-25	2%	615	625	27.33	27.78	27.55

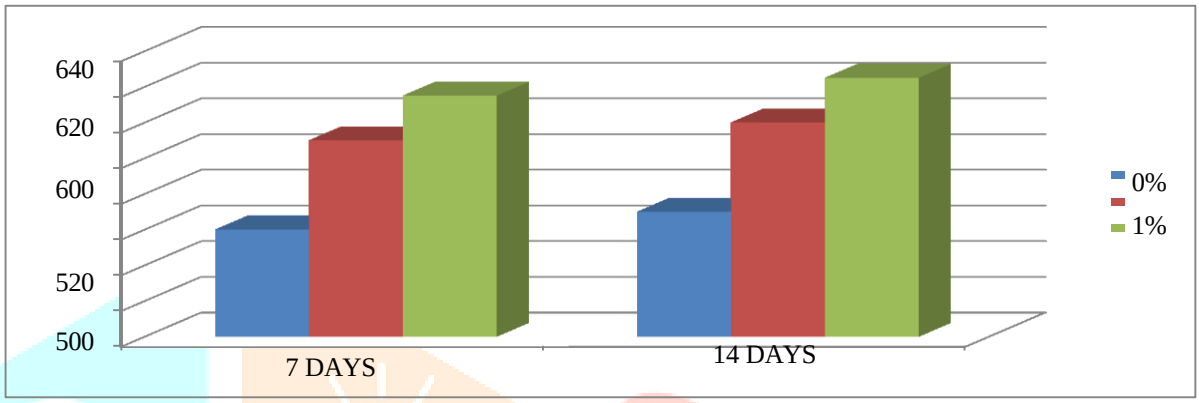


Chart 5.4

Result For M-20 Grade Concrete Cubes:-

Sr. No.	Concrete Grade	% Hair & Jute	Max. Load Recorded (KN)		Compressive Stress (N/mm^2)		Compressive Stress (N/mm^2)
			7 Days	14 Days	7 Days	14 Days	Average
1.	M-20	0%	410	430	18.22	19.11	18.66
2.	M-20	1%	460	600	20.44	26.67	23.55
3.	M-20	2%	550	560	24.44	24.89	24.66

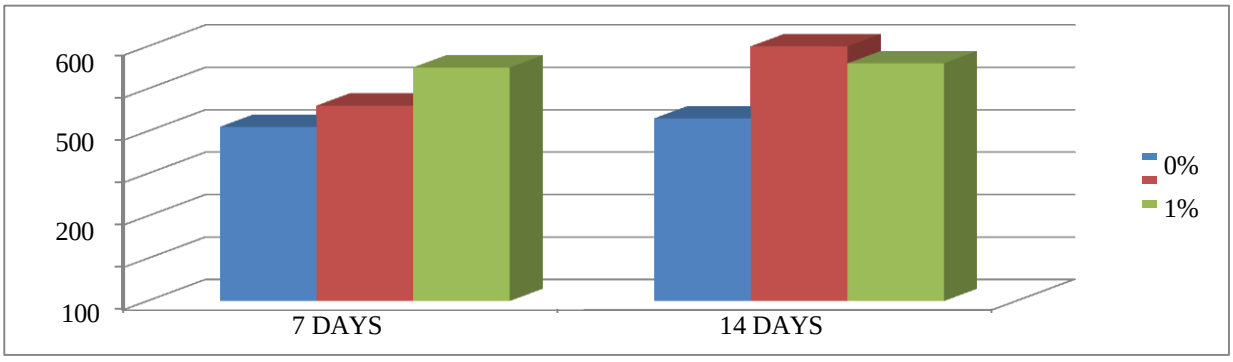


Chart 5.5

Result For M-25 Grade Concrete Cubes:-

Sr. No.	Concrete Grade	% Hair & Jute	Max. Load Recorded (KN)		Compressive Stress (N/mm^2)		Compressive Stress (N/mm^2)
			7 Days	14 Days	7 Days	14 Days	Average
1.	M-25	0%	540	550	24	24.44	24.22
2.	M-25	1%	600	620	26.67	27.56	27.11
3.	M-25	2%	625	640	27.78	28.44	28.11

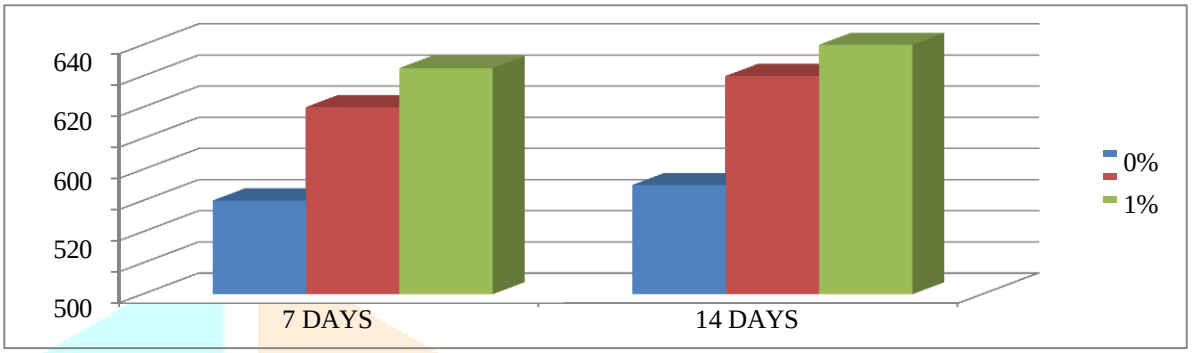


Chart 5.6

Conclusion

6.1 Conclusion of cube:

As per the comparison test of result it is observed that there is increment in properties of concert according to percentage of hair by weight of in concrete. When M-20 concrete with 1% hairs compared with plain concrete, it is found that there is increase of 15% in compressive strength. When M-20 concrete with 1% Jute compared with plain concrete, it is found that there is increase of 14% in compressive strength. When M-20 concrete with 1% Hair and Jute compared with plain concrete, it is found that there is increase of 17% in compressive strength. When M-20 concrete with 2% Hair compared with plain concrete, it is found that there is increase of 16% in compressive strength. When M-20 concrete with 2% Jute compared with plain concrete, it is found that there is increase of 15% in compressive strength. When M-20 concrete with 2% Hair and Jute compared with plain concrete, it is found that there is increase of 18% in compressive strength. When M-25 concrete with 1% Hair compared with plain concrete, it is found that there is increase of 16% in compressive strength. When M-25 concrete with 1% Jute compared with plain concrete, it is found that there is increase of 15% in compressive strength. When M-25 concrete with 1% Hair and Jute compared with plain concrete, it is found that there is increase of 18% in compressive strength. When M-25 concrete with 2% Hair compared with plain concrete, it is found that there is increase of 17% in compressive strength. When M-25 concrete with 2% Jute compared with plain concrete, it is found that there is increase of 16% in compressive strength. When M-25 concrete with 2% Hair and Jute compared with plain concrete, it is found that there is increase of 21% in compressive strength.

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