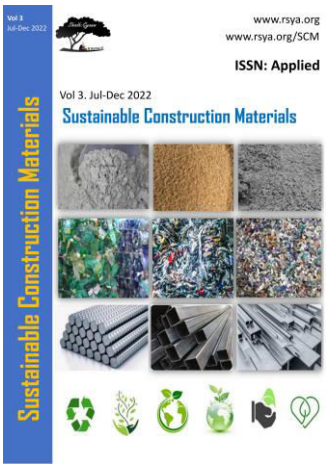

www.rsya.org

Sustainable Construction Materials

Vol 2, Issue 2, Jul-Dec 2022
www.rsya.org/scm

Utilization of Horse Hair Fibre in Rigid Pavement as a Fibre Reinforcement Material

Shyam Sharma, Manoj Kumar Tomar, Roopa Iyer*

Rajiv Gandhi Institute of Technology, Kottayam, India, 686501

*Corresponding author: iyerroopa89@gmail.com

Abstract: Since the start of this century, more people have realised that non-renewable resources are running out and that the future will be powered by renewable energy. This century will be the foundational century as we employ more renewable, recyclable, and reusable resources. Natural fibres are one of the most sustainable resources. Natural fibres are not new. Horse hair was used for mortar and straw for mud blocks. Natural fibres are also made from sisal, coco, bamboo, jute, and elephant grass. Pollution reduction and recycling rates are currently being prioritised. Researchers are testing novel methods to repurpose waste material in concrete. Waste horse hair concrete containing 0, 0.5, 1, and 1.5 percent horse hair by weight of cement is being regulated for cooling, physical, and mechanical qualities. Concrete production includes these horse hair percentages. After 28 days, the results of concrete trials with zero, half, one, and one and a half percent horse hair fibre were analysed. After 28 days, compression strength increased 13.7 percent, 18.7 percent, and 26.6 percent for 0.5 percent, 1 percent, and 1.5 percent horse hair, respectively, while flexural strength increased 15 percent, 18.84 percent, and 26.08 percent.

Keywords: Natural Fibre, Sustainable, Recycle Waste, Horse Hair

INTRODUCTION

Small particles of reinforcing material that have a multitude of qualities that are unique to themselves are called fibres. The buildup of fibres in concrete has an effect on its mechanical qualities and its ability to be manoeuvred, both of which frequently depend on the size and proportion of the fibres. [1-3]. Concrete breaks easily and has a tendency to crack under tension because of its brittle nature. Because of this, the incorporation of fibres into concrete results in an increase in its tensile strength and an overall improvement in its properties [4]. Concrete that has been strengthened with horse hair is known as concrete with horse hair reinforcement. The concrete contains horse hair in an even distribution, yet the hair's orientation is completely haphazard. In the course of horse history, numerous attempts have

been made to use natural fibre as a form of reinforcing material. For example, in the early 1900s, concrete was experimentally treated with asbestos fibres [5], and In the 1950s, the notion of composite materials was presented, and one of the topics of interest at the time was fiber-reinforced concrete. Due to the numerous dangers involved, the use of asbestos in the construction industry as a reinforcing material is not recommended.

Reasons to use fibre as reinforcement

1) Drying shrinkage and plastic shrinkage can both be controlled by the addition of fibres.
2) There will be less water seepage through the concrete as a result of the reduction in its permeability.
3) The presence of fibres has a significant impact on the abrasion resistance, shatter resistance, ductility, and strength of concrete.
4) Reinforcing the mortar with fibres prevents cracks from appearing as quickly.

Effects of fibres in concrete

In concrete, the presence of multiple types of fibres results in increased resistance to shock, abrasion, and fracture. Fibers cannot improve the flexural strength of concrete and cannot take the place of steel reinforcement in a structure that needs to be able to withstand moment loads. Even more fibres can bring to a reduction in the overall strength of the concrete. Fibers are often added to concrete mixes in the form of percentages that are referred to as "volume fractions" (Vf). These percentages commonly range from 0.10 to 3.0 percent. To calculate the aspect ratio, just divide the fibre length by the fibre diameter (length to diameter). When dealing with fibres that are not circular in shape, the aspect ratio of the fibre can be determined by utilising the equivalent diameter [6]. Fibers that have a higher modulus of elasticity than a matrix can potentially have a higher tensile strength than a matrix, which means they are better able to support a load. Strength and toughness are both increased in the matrix when it contains fibres with a larger aspect ratio.

Major benefits of fiber-reinforced concrete

It is used in structures that require the elimination of corrosion as much as possible. It is best to use fibre reinforced concrete for structures with high velocity flows, such as sluice-ways, navigational locks, and bridge piers, in order tominimize the damage caused by cavitation and erosion with thinner FRC over thicker plain concrete, weight savingscan be significant. Using FRC in bridge construction can minimize damage and help prevent catastrophic failures [7]. Fibre-reinforced concrete will significantly minimize casualties in earthquake-prone areas by reducing internal forces. The fibres will prevent tiny cracks from forming within the concrete.

Consequences to consider when working with fiber-reinforced concrete

The fact that fibre reinforced concrete cannot produce a blend of fibres and concrete that is consistent throughout is the primary limitation of this material. In order to produce plain concrete that is less expensive, it is necessary to incorporate fibres into the cement matrix, which is a labor-intensive procedure that results in higher costs. Despite this, the genuine benefits of FRC much outweigh the aforementioned drawbacks.

Purpose of horse hair fibre

1) Horse wire is as strong as copper wire of the same diameter.
2) The ability to recycle the non-biodegradable waste product that is horse hair would be beneficial to the environment.
3) Horse hair may be obtained practically everywhere, and it's cheap or even free.
4) It helps keep the mortar in place so it doesn't run out.
5) Unlike steel bars, it is not susceptible to rust.

FIGURE 1. Sample of Horse Hair

LITERATURE REVIEW

According to the study conducted by Riya Babu et al. (2015), the percentage of concrete's weight that is comprised of hair grows significantly over time. The addition of various hair fibres increases the concrete's compressive strength by 1% to 12% and its bending strength by up to 5%. Compressive strength is greatest in low rock mixes, making hair fibre reinforced concrete ideal for usage with such mixtures. [8]. Horse hair's impact on the flexural strength and compressive strength of M20 concrete is studied in a 2012 study (Jain.D et al. The results were correlated with the same concrete and the samples were thrown aside. The author noted a rise in both compressive strength (8.8 percent) and flexural strength (11.1% at 2 percent hair content) (5.5 percent) [9]. Horse hair fibres added to concrete have been the subject of research by G.Sreevani et al. (2017), who found that the material had improved compressive strength and split tensile strength. This research demonstrates that incorporating horse hair into concrete not only modifies its physical qualities (such as its compressive and tensile strengths), but also enhances its bonding and controls microcracking. Controlled condensation happens at a slower pace after the inclusion of limit fibres, as verified by Yadollah Batebi et al., 2013 [10]. The author conducted research showing that after 40 days, the volume of concrete with added hair decreased by 33%. This decrease in NHRC is equivalent to 90.5% based on the average weight of hair fibres of 60 mm in length. [11]. Compressive strength of cement concrete increased 3.51% after 7 days when 1% horse hair was added, as shown by research by Mridula Dwivedi et al. (2017). The compressive strength of concrete containing 3 percent horse hair in addition to cement was found to be 6.7% higher after 7 days of curing than before curing. The compressive strength of concrete containing 1 percent horse hair in addition to cement was 5.4% higher after 28 days of testing than before. Flexural strength was shown to be increased by 28.48% when comparing horse hair pluscement concrete with normal concrete after 7 days. The bending strength of concrete containing 1 percent horse hair in addition to cement increased by 36.35 percent after 28 days, according to a comparison test. [12].

METHODOLOGY

i) The compressive strength of hardening concrete can be evaluated using a simple test known as a

compression test, and the features necessary for testing actually improve the concrete. 15 by 15 by 15 centimetres The size was measured after compression. To begin, a cast iron mould was utilised to create a specimen to specification. Each layer of concrete, no matter its hair percentage, was tamped with a bar at least 35 times. The mould was then transferred to a vibrating table, where it underwent additional compression until the desired consistency was reached. After mould had been removed from the samples for 24 hours, they were submerged in clean water. After 28 days in a load-bearing machine, a compressive test was conducted on the samples.

ii) Flexural test - Directly measuring concrete's tensile strength is a time-consuming and inaccurate process. There hasn't been a tool developed that reliably keeps the force distributed evenly until now. Extreme fibre stress in bending is a function of the applied loads and beam cross section. The flexural tension in a beam can be calculated using the third-point loading method. The highest amount of bending moments occurs in the middle third, when the crucial crack can form anywhere.

iii) The workability test was carried out using a slump cone mould with a 5 cm upper radius, 10 cm lower radius, and 30 cm height. It was greased lightly and then placed on a nonabsorbent flat surface. Before adding water, concrete was properly mixed to ensure a consistent appearance. The mould was filled with concrete mixture to within a quarter of its height. The concrete was packed down evenly with a tamping rod. Half of the concrete is poured into the mould and compressed twice. The mould began to rise vertically almost instantly after being taken out. The necessary slump of concrete was determined by measuring the concrete's subsidence in millimetres after settling was complete.

EXPERIMENTAL WORK

Different mixtures were created using cement components containing 0 (no Horse Hair Fibre), 0.5 (some Horse Hair Fibre), 1 (some Horse Hair Fibre), or 1.5 (some Horse Hair Fibre). As a point of comparison, we used a batch of plain concrete that had no Horse Hair Fibre whatsoever.

A mixture of horse hair fiber reinforced concrete (M25 fine) and concrete: The mix proportions of other mixes were derived using the reference mix as a control. In Table 1, we present the proportions of the fibre-assimilation mix that contains 0.5% fibre.

TABLE 1: Ratio of material in M25

Material	Water	Cement	Fine aggregate	Coarse Aggregate
Kg/m^3	186	294	724.888	1173.946
Ratio	0.6	1	2.466	3.992

Casting of specimens

1. The above equation is used to determine the mass of the substance when a combined control design (such as no horse hair) is used in the application. The percentages of HHF in the mixtures are 0.5%, 1.0%, and 1.5%, respectively, based on the total cement weight. The data points were converted to the 0.5 weight-to-bulk ratio.
2. Blending Designs One hundred percent to zero Horse\shair Combo of Designs Two times 0.5 percent Designing using horse hair From 3 to 1 percent Texture of horse hair
3. Hybridization in Design 14 to 15 of 1% Animal hair
4. To find out if the concrete could be worked, a slump cone test was performed.
5. The following experiments were conducted on 28-day-old concrete samples to characterise their hardened qualities.
6. Squeezing for strength

7. Flexion Strength Evaluation

RESULTS

1) **Compressive Strength –** Compressive strength is determined with a cement replacement of 0%, 0.50%, 1%, and 1.50% hair content, respectively. In tests, the typical concrete block of 150 mm thickness is used. Compressive energy is dissipated at a rate of three cubes per percentage of horse hair. As can be seen in figure 2, after 28 days there is a 1.5 percent rise in compressive strength.

TABLE 2: Compressive strength for different hair content

S. No.	% of Hair	Avg. Compressive Strength (N/mm^2)
1	0%	571.23
2	0.5 %	663
3	1 %	705.776
4	1.5 %	765.467

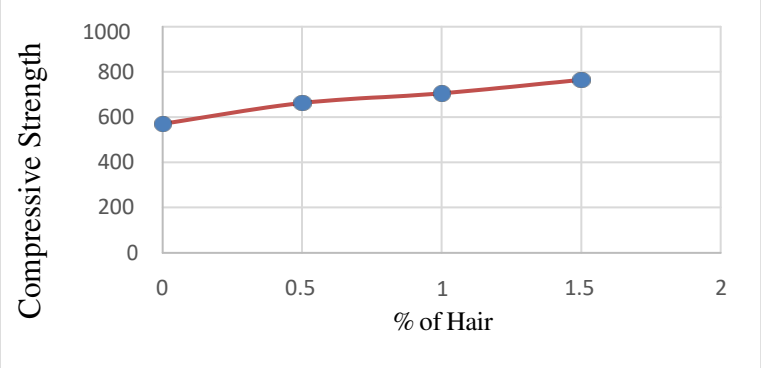

FIGURE 2. Compressive strength for various % of hair content

Flexural strength – Cement replacements with varying percentages of hair content (0.5%, 1%, and 1.5%) are tested for flexural strength. For these tests, regular 150mm x 150mm concrete beams are used. Three cubes of flexural force are extracted for every percentage of horse hair. Figure 3 displays the results of a 28-day study that indicated a 1.5-percent increase in flexural strength.

Slump Value- Table 1 shows the results of a slump cone test conducted on a mixture containing 0%, 0.5%, 1%, and 1.5% horse hair. Figure 4 shows that the rate of hair loss increases with the percentage of hair, but the amount of hair drops by 1.5%.

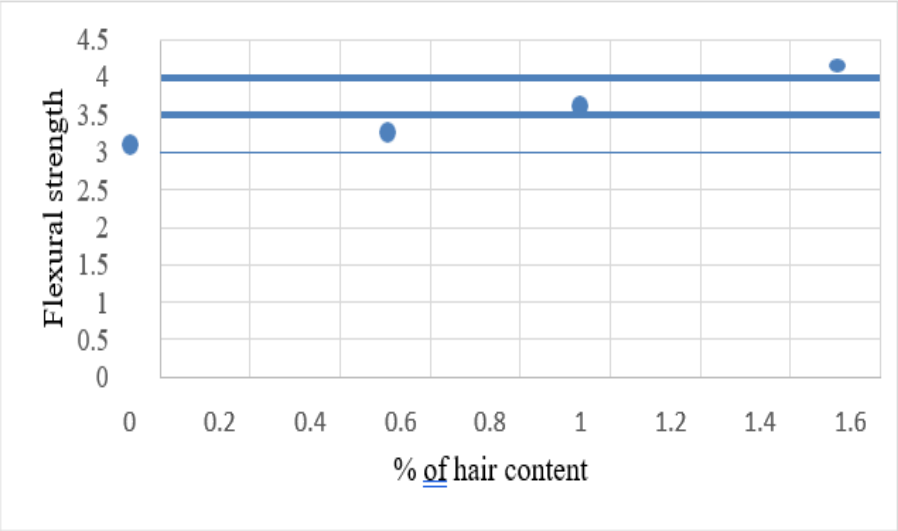

FIGURE 3. Flexural strength for various % of horse hair

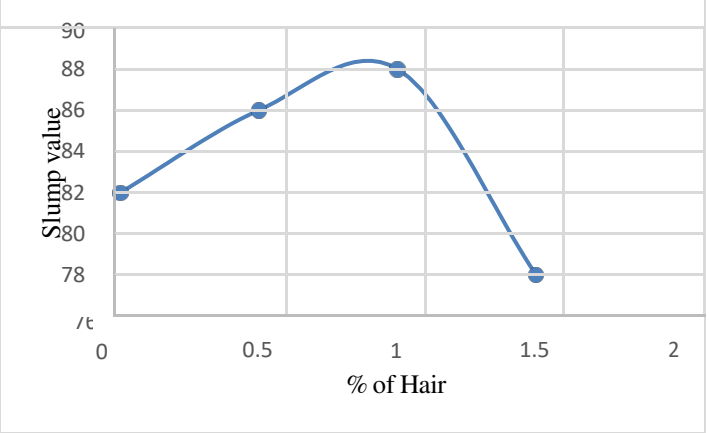

FIGURE 4. Slump for different hair content

TABLE: 3 Flexural strengths for various % of horse hair

S. No.	% of Hair	Maximum Load (KN)	FS (N/mm^2)
1	0 %	8.5	3.107
2	0.5 %	9	3.252
3	1 %	10	3.620
4	1.5 %	11.5	4.108

TABLE 4: Slump for different hair content

S. No.	% of Hair	Slump Value (mm)
1	0 %	82
2	0.5 %	86
3	1 %	88
4	1.5 %	78

CONCLUSIONS

Compression strength was increased by 571.2 N/mm2 and 765.4 N/mm2 in concrete that contained 0.5 and 1.5 percent horse hair, respectively. The flexural strength of concrete with 0.5% horse hair increased to 3.107 N/mm2, and that of concrete containing 1.5% horse hair increased to 4.10 N/mm2. The concrete's workability dropped by about 1.5% after the hair content was increased. The figure emphasises various fractions of hair, such as 0%. It may be concluded that hair-reinforced concrete should not be employed in workable concrete since its workability declines with increasing amounts of hair. Since adding horse hair to concrete can increase its compressive and flexural strengths by up to 1.5 percent, this byproduct of horse activity should be put to good use in the construction industry.

REFERENCES

[1] N. Bheel, M.A. Jokhio, J.A. Abbasi, H.B. Lashari, M.I. Qureshi, A.S. Qureshi, *"Rice Husk Ash and FlyAshEffects on the Mechanical Properties of Concrete", Eng. Technol. Appl. Sci. Res.* 10 (2), 2020, pp. 5402– 5405.

[2] N. Bheel, A.W. Abro, I.A. Shar, A.A. Dayo, S. Shaikh, Z.H. Shaikh, "*Use of Rice Husk Ash asCementitious Material in Concrete", Eng. Technol. Appl. Sci. Res.* 9 (3*), 2019,* pp. 4209– 4212.

[3] N. Bheel, K.A. Kalhoro, T. A. Memon, Z.U.Z. Lashari, M.A. Soomro, U. A. Memon, 2020 "*Use of MarblePowder and Tile Powder as Cementitious Materials in Concrete", Eng. Technol. Appl. Sci. Res.* 10(2),2020, pp. 5448–5451

[4] A. K. Parashar, P. Sharma, and N. Sharma, "Effect on the strength of GGBS and fly ash based geopolymer concrete," Mater. Today Proc., Apr. 2022, doi: 10.1016/J.MATPR.2022.04.662

[5] Mredula D., Dr. R.K.Dixit, "Study *on Reinforced Concrete with Horse Hair as Fibre", International Journalof Innovative Research in Science, Engineering and Technology. Vol. 6, Issue 10, .2017, DOI:10.15680/IJIRSET.2017.0610008.*

[6] Kumar Shantverayya and Sugunashree SM, "*Performance of Hair Reinforced Concrete" InternationalJournal of Applied Research,* 3(1)*, 2017,* pp. 582-586.

[7] Jain D. and Kothari A. *"Hair Fibre Reinforced Concrete" Research Journal of Recent Sciences, Vol. 1(ISC-2011),* pp.128-133.

[8] Nila, V. M, Raijan , K. J., Susmitha Antony, Riya Babu et al.*"Horse Hair as Fibre Reinforcement inConcrete: An Alternative Method of Hair Waste Management And its Applications in Civil Construction"International Journal of Current Research Vol.7, Issue, 10, 2015,* pp.21205- 21210.

[9] D. Jain, A. Kothari,*"Hair Fiber Reinforced Concrete", Res. J. Recent Sci. 1,2012,* 128–133. *[10]* Sreevani, G., and Ajitha, B.S.,*"Horse Hair as Fibre reinforcement in concrete", International Journal ofEngineering Science and Computing, Volume 7, No. 5,2017,* pp. 11358-11364.

[11] Abubaker A. M. Ahmed and Yanmin Jia, *"Effect of Using Hybrid Polypropylene and Glass Fibre on theMechanical Properties and Permeability of Concrete" Materials (Basel). 2019 Nov; 12(22): 3786. DOI: 10.3390/ma12223786*

[12] Mridula Dwivedi, Dr. R.K. Dixit,*"Study on Concrete Reinforced with Horse Hair as Fibre" InternationalJournal of Innovative Research in Science, Engineering and Technology. Vol. 6, Issue 10, 2017, DOI:10.15680/IJIRSET.2017.0610008*