Journal of Innovations in Engineering Education
JIEE 2023, Vol. 6, Issue 1.

https://doi.org/10.3126/jiee.v6i1.39208

THAPATHALI CAMPUS
Institute of Engineering
Tribhuvan University

Analysing the optimum effect of the human hair waste as fiber reinforcement in M20 grade concrete

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ARTICLE INFO

Article history:

Received 18 Aug 2023
Revised in 20 Nov 2023
Accepted 4 Dec 2023

Keywords:

Fiber Reinforced Concrete
Human Hair Fiber
Compressive strength
Flexural strength

Abstract

Human hairs are considered as unused waste material which are non-degradable and are found in abundance in urban cities like Kathmandu. Human hair as a solid waste has multifaceted environmental problems and the main aim of this study is to utilize such unused human hair to enhance the properties of concrete. Human hair as a fiber possesses high tensile strength property and can be used in concrete to enhance compressive and tensile strength properties of concrete. In this experimental study, experiment was performed on M20 grade concrete mix with varying percentages of human hair fiber i.e., 0%, 0.50%, 1.00%, 1.25%, 1.50%, 1.75 and 2.00% by weight of cement to analyze the compressive and flexural strength. To analyze the workability of the mixes slump test was performed. Test results showed that compressive strength and flexural strength increased up to 1.50% of human hair fiber content and decreased beyond 1.5% which shows that optimum HHF content for our study on M20 grade of concrete is 1.5%. Hence, human hair can be used in concrete to enhance its compressive and flexural properties and will be the alternative way of salon hair waste management.

1. Introduction

Management of solid waste is one of the major challenges for urban cities like Kathmandu. Human hair as solid waste are unused materials and are found in abundance in cities like Kathmandu. The decomposition of human hair is very slow and often in large amount in solid streams may cause choking on drainage systems, also in dumping site it occupies large volume. Human hair as a solid waste has multifaceted environmental problems and the objective of this study is to utilize such unused human hair to enhance the properties of concrete.

Concrete is widely used construction material which is composite mixture of cement, coarse aggregate, fine aggregate and water. From ancient to present day, fiber such as steel, glass, synthetic and other natural fibers are extensively used in concrete and named as Fiber Reinforced Concrete (FRC). Study have shown that these fibers used in concrete have enhanced the compressive strength and flexural strength properties of concrete and have also positive effect on shrinkage and crack control properties of concrete.

In this paper, Human Hair Fiber (HHF) are used as fiber in FRC and studies the impact of HHF on Compressive and Flexural strength properties of concrete.

2. Objectives of the study

The main objective of the study is to investigate and compare the compressive and flexural strength of M20 grade concrete with the use of different proportion of Human Hair Fiber (HHF). Besides this, the specific objectives of the study are to investigate about:

- To study the overall effect of HHF in concrete.
- To evaluate the compressive strength of concrete with the integration of HHF in different proportions for M20 grade of concrete.
- To evaluate the flexural strength of concrete with the integration of HHF in different proportions for M20 grade of concrete.
- To know about the use of the optimum percentage of HHF in concrete.

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- To study the effect of the proportion of HHF on the workability of concrete.

3. Limitations of study

The study aims to evaluate selected compressive strength, flexural strength and workability parameters with the integration of human hair fiber in different proportions. The study is limited to;

- Concrete grade of M20 was used.
- Length of hair used was 3.5 cm long, and diameter is neglected.
- Only female hair has been used.

4. Materials and methodology

4.1. Materials

Ordinary Portland cement (OPC)-53grade Hetauda cement was used in this experiment. Crushed angular coarse aggregates 20 mm down and fine aggregates 4.75 mm down sieve size grade confirming to IS 383-1970 were used. Human hair fiber used as fiber reinforced were taken from Hair Salon shops from different parts of the Kathmandu City and the length of HHF used in concrete mix were 3.5cm long.

4.2. Mix proportions

Concrete mix design was performed according to the IS 10262-2009. From concrete mix design, mix proportion of 1:1.81:3.0 (Cement: Sand: Aggregate) and water cement ratio 0.5 was determined. The quantity of HHF was fixed with respect to weight of cement.

For our study, concrete mix containing 0% HHF was considered as a control mix and used as a reference. Further, HHF 0.5%, 1.0%, 1.25%, 1.5%, 1.75% and 2.00% by the weight of cement was used in the concrete mix. Overall, 7 different concrete mix were performed containing HHF 0%, 0.5%, 1.0%, 1.25%, 1.5%, 1.75% and 2.00% by the weight of cement.

4.3. Methodology

After determining the mix proportions for concrete from concrete mix design, 7 different batches of concrete mix were performed containing HHF 0%, 0.5%, 1.0%, 1.25%, 1.5%, 1.75% and 2.00% by the weight of cement. For determining compressive strength, cube moulds of size 15cm*15cm*15cm were filled and compacted properly and placed in curing tank after 24 hours. Similarly, for determining flexural strength, concrete beam of size 75cm*15cm*15cm were filled and compacted properly and placed in curing tank after 24 hours. The concrete cubes and concrete beams were tested after 7 days and 28 days of casting concrete for determining compressive strength and flexural strength respectively.

5. Tests performed

5.1. Slump test

Slump test is considered as the simplest and quickest method to measure the workability of concrete. Workability measures the consistency of fresh concrete. It is also an indicator of an improperly mixed batch of concrete. Slump test was performed to determine the workability of fresh concrete. For slump test, frustum of cone of size 10cm internal diameter at the top, 20cm internal diameter at the bottom and 30cm height was used. The cone was filled with fresh concrete at three layers and tamped 25 times in each layer with tamping rod. The slump value of concrete was determined by measuring the distance of slumped concrete from top to bottom of frustum of cone.

5.2. Compressive strength test (Cubes)

To determine the compressive strength of concrete, concrete cubes of size 15cm*15cm*15cm were tested on Compressive Strength Testing Machine after 7 and 28 days of casting. The specimen cubes were taken out from the curing tank and surface dried. After that, cubes were placed in the Compressive Strength Testing Machine centrally between the upper and lower plates. The compressive strength test was done as per IS 516-1959. The load was applied uniformly at 340 kN/minute. The ultimate crushing strength was noted and average strength of three cubes was calculated. The process was repeated for all the sample cubes.

5.3. Flexural test on concrete (Beams)

To determine the flexural strength of concrete, concrete beams of size 75cm*15cm*15cm were tested on Flexural Strength Testing Machine after 28 days of casting. The specimen beams were taken out from the curing tank and surface dried. After that, beams were placed in the Flexural Strength Testing Machine. Load was continuously applied to the failure at the rate of 400 Kg/min. The ultimate crushing strength was noted and average strength of three beams was calculated. The process was repeated for all the sample beams.

6. Results And Discussion

6.1. Workability

To measure workability slump test was performed as per IS 1199:1959. The following bar chart shows the slump value with respect to different percentage of human hair fiber used in concrete.

From above bar chart diagram, it shows that slump

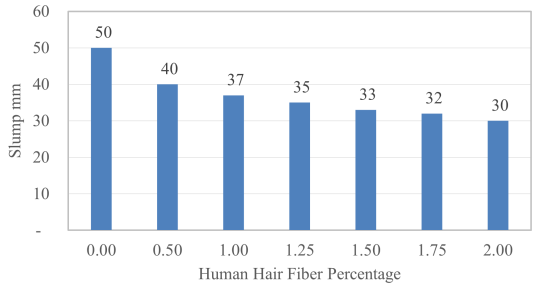
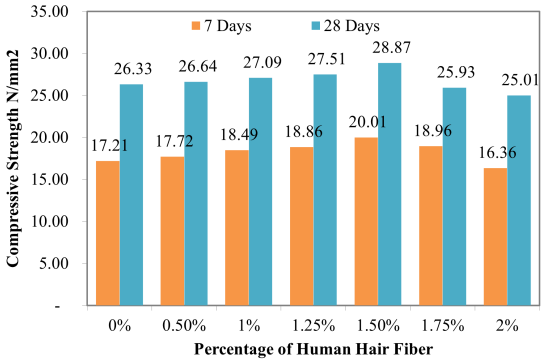


Figure 1: Slump Cone Test Result



value decreased with increase in human hair fiber percentage. With the increase in human hair fiber percentage, it was observed that started to form ball and segregation in concrete mix and started to less workable.

6.2. Compressive strength

Compressive strength test was carried out after 7 days and 28 days of casting. The result of compressive strength test of 7 days and 28 days are shown as shown in Fig below.

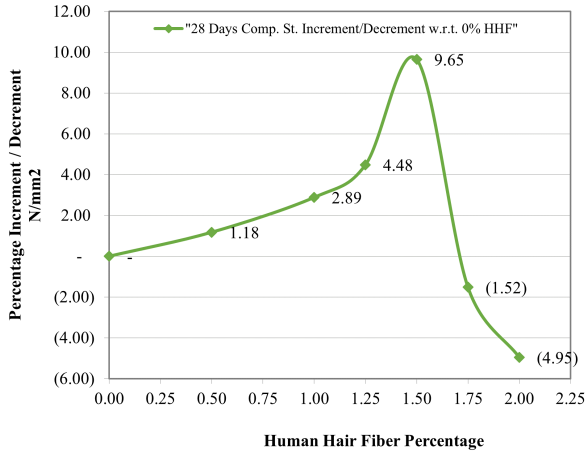


Figure 2: 7 Days and 28 Days Average Compressive Strength Analysis

From above diagrams, it can be observed that 7 days and 28 days average compressive strength was maximum 20.01 N/mm^2 and 28.87 N/mm^2 respectively at 1.5% HHF concrete mix and decreased with the increase in HHF. It was observed that 28 days compressive strength maximum 9.5% increment in compressive strength at 1.5% HHF by weight of cement. The optimum HHF was determined at 1.5% which implies that compressive strength of concrete increase up to certain percentage of HHF and start to decrease with further increment in HHF percentage.

6.3. Flexural strength

The flexural strength of concrete is carried out at 28th days of casting of beams under testing machine. The result of flexural strength test of 28 days is shown below.

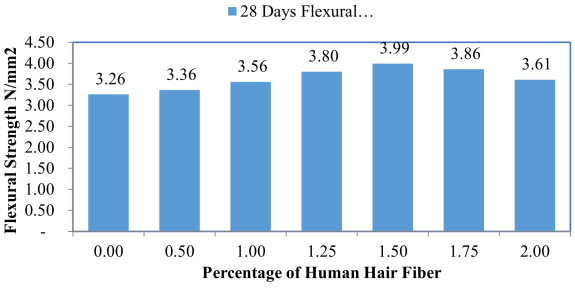


Figure 3: 28 Days Flexural Strength, N/mm^2

From above Figure, it can be observed that the 28-day average flexural strength obtained was maximum 3.99 N/mm^{2}at 1.5% HHF mix concrete and minimum average compressive strength was 3.26 N/mm^2 at 0.00% HHF mix concrete. The average flexural strength increased from 0% hair fiber mix to the 1.5% hair fiber in mix, then started to decrease but at 2% hair fiber concrete mix flexural strength was above the control mix.

7. Summary and conclusions

Human hair as a solid waste which are non-degradable are causing a lot of environmental problems in cities like Kathmandu. Human hair as a fiber possesses high tensile strength property and can be used in concrete to enhance compressive and tensile strength properties of concrete.

In our study, Human Hair Fiber (HHF) at different proportion from 0-2% by weight of cement on M20 grade of concrete were mixed and the effect of HHF on workability, compressive and tensile strength properties of

concrete were studied. Our results showed that both compressive strength and flexural strength increased up to 1.5% of HHF and decreased beyond 1.5% which shows that optimum HHF content for our study on M20 grade of concrete is 1.5% due to homogeneity of mix proper bond formation and decrease after 1.5% due to formation of ball and segregation on mix.

Acknowledgement

The authors are thankful to Pulchowk Campus and Everest Laboratory Pvt. Ltd. for providing laboratory facilities and Kamala's Beauty Hair Salon for providing the HHF during the research work.

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