

**USE OF HUMAN HAIR FIBER AS A REINFORCEMENT IN A CEMENT
FIBERBOARD**



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College of Engineering Education
University of Mindanao**

**In Partial Fulfillment
of the Requirements for the Degree
Bachelor of Science in Civil Engineering**

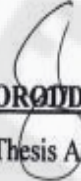
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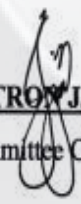
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
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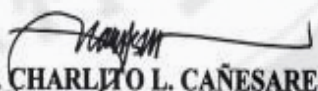

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ABSTRACT

Human hair is a waste that needs to be disposed of properly since this waste has an unlimited supply and will take time to decompose. Proper utilization and repurposing of this waste will make the environment cleaner by developing cement fiberboard products. Reinforcing the cement will be a step up since hair fiber is an excellent addition to the cement's characteristics due to the hair's high tensile strength. This research aims to study the utilization of human hair fiber as a reinforcement in cement fiberboard and specifically to evaluate its effect, particularly on bulk density, water absorption, flexural strength, compressive strength, and fireproof capability, by following the American Society for Testing Materials (ASTM) guidelines. All these tests will be performed to observe the effectiveness of using human hair fiber in a cement fiberboard. Based on the results, adding a percentage of human hair fibers to a cement fiber board will improve some of the mechanical properties of the board, especially the flexural strength, proving that hair fibers have excellent tensile strength. The addition of human hair fibers increased the strength of the boards compared to controlled mixed samples, which proved that these fibers could be used as a viable alternative natural fiber for cement fiberboard and will also reduce human hair waste.

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Use of human hair fiber as a reinforcement in cemen fiber board

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Abstract— Waste materials like human hair are abundant in everyday life and produced in large quantities that cannot be putrefied. This waste is responsible for clogging sewage lines and polluting the environment. However, one advantage of human hair is its tensile strength. The tremendous tensile strength of human hair makes it comparable in strength to the copper wire of the same diameter. As a result, human hair is used as a reinforced fiber in concrete. This research aims to study the utilization of human hair fiber as a reinforcement in cement fiberboard and to evaluate its effect, particularly on bulk density, water absorption, compressive strength, flexural strength, and fireproof capability. After 28 days of curing, the 250mmx250mmx10mm and 70mmx70mmx70mm samples with a design mix ratio of 3:1 (cement: sand) where cement was replaced by human hair fibers by weight percentages of 1%, 1.5%, and 2%, and plain concrete with 0% human hair fiber as the controlled mix and a water-cement ratio of 0.46 were tested for their mechanical properties. Based on the results, adding human hair fibers to a cement fiber board can improve some of the mechanical properties of the board, especially the flexural strength, proving that hair fibers have excellent tensile strength. The addition of human hair fibers increased the strength of the boards compared to controlled mixed samples, which proved that these fibers could be used as a viable alternative natural fiber for cement fiberboard and will also reduce human hair waste.

Keywords— *Cement fiber board (CFB), Human hair fiber (HHF), Acetone, Tensile, Copper wire*

I. INTRODUCTION

The Philippines has a population of approximately 113.9 million, and this number of people will contribute to producing waste material from the body, such as nails, earwax, sweat, and human hair. These wastes can be massive environmental pollutants and harmful to people's health when they are not correctly disposed of, like hair dust, which leads to tuberculosis, and hair fumes when burned, leading to lung failure [1]. Human hair waste is found in abundance in everyday life. These waste are produced in large quantities and estimated to be 6.9×10^5 tonnes each year [2] and cannot be easily

putrefied, which can end up in the streams or drainage systems in the community, where it will take several years to decompose [3]. With a population of approximately 2,770,000, Quezon City is in the number one spot. Next is Manila, which has approximately 1,600,000 people, and the third City has a population of 1,500,000, which is Caloocan. The fourth is Davao City, which has 1,215,000 people. These significant cities produce human hair waste daily.

Since the earliest days, numerous researchers have studied human hair as a reinforcement in concrete because it is the most affordable and environmentally friendly fiber [4]. Hair fibers are formed by a protein known as keratin, which gives the hair flexibility, strength, and durability [5]. This kind of fiber became the optimum researchable material due to its tremendous tensile strength, which enhanced the performance of concrete and reduced environmental pollutants. The tensile strength of these fibers was similar to that of a copper wire with the same diameter [6]. Hair fibers were used as a secondary reinforcement to prevent the concrete from forming hairline cracks and control drying and plastic shrinkage [7]. Also, these fibers were considered a stabilizing agent, and with the specific length and diameter, these fibers were used to strengthen the weak soil and improve the soil's durability [8].

Cellulose fibers are the key ingredient for cement fiber board, and cellulose fibers can be produced in plants, wood, and vegetables [9]. Strong typhoons, floods, climate condition and grass fires can affect the size and quality of a natural fiber which results to a huge problem in cultivating cellulose fibers [10]. For this reason, this will have a huge impact on the future of the construction industry since the country is now a progressive country. In the near future, all of these construction products will increase in price due to demand. The cost of concrete board is rising daily as a result of the use of naturally occurring materials, making it uneconomical for structural purposes. Fibers can be used to control the hairline cracks and pores that develop in concrete as a result of plastic and drying shrinkage [11] and in order to reduce permeability

and bleeding water. Fibers like polypropylene fibers, nylon fibers, tailored fibers, glass fibers, and carbon fibers have been used to overcome these obstacles and create practical economic solutions [7]. For this reason, human hair can be a huge alternative to cellulose fibers by utilizing human hair that is only waste and make it useful, that is why natural fiber like human hair was used in this study as a reinforcement in cementfiber board.

The main objective of this research is to study the utilization of human hair fiber as a concrete additive to develop a cement fiber board with natural fibers. Specifically, to evaluate the effect of human hair fiber as a reinforcement of the cement fiberboard, particularly with bulk density, water absorption, fire capability, compressive strength and especially with the flexural strength.

This research aims to study human hair fiber's utilization in cement fiber board with natural fibers. Specifically, to evaluate the effect of human hair fiber as a reinforcement of the cement fiberboard, particularly with bulk density, water absorption, fire capability, compressive strength, and especially with flexural strength.

This study benefits both the construction industry and the environment. Using human hair on a cement fiberboard could help the construction industry search for affordable and practical building materials that can be used in the future. At the same time, using human hair fibers can reduce the problem of human hair waste.

This research focuses on using varying percentages of human hair fiber as a concrete additive and reinforcement of the cement fiber board. In this study, the researchers investigated the effect of human hair fiber on physical and mechanical properties like water absorption, bulk density, compressive strength, and flexural strength.

II. MATERIALS AND METHODS

A. Conceptual Framework

Figure 1 shows the conceptual framework of this study using an input-process-output system. In the first stage, the researchers gathered all the materials needed. The second stage focused on preparing the materials required for the study, and the researchers did all the particular tests with the samples. The last step was evaluating the specimens. Specimen with a total of 25 pieces with different percentages of human hair fiber by: 0%, 1%, 1.5%, and 2%.

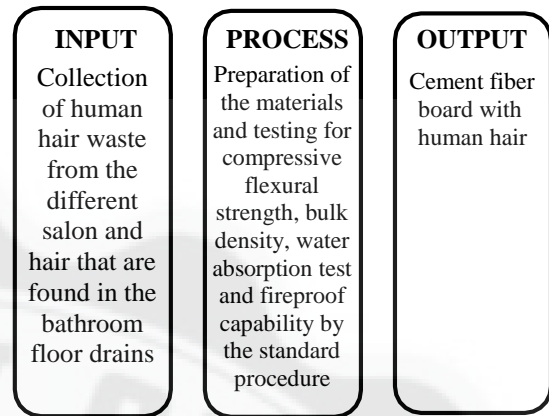


Fig 1. Conceptual Framework of the Study

B. Materials and Resources

Type I Portland cement, local fresh water, and fine sand that passed through sieve no. 8 and retained in sieve no. 200 were used for this study and acquired in the nearest stores. The human hair waste was collected from some households' bathroom floor drains and salons.

C. Methods and Procedures

1. Mixture Proportion

The mortar-designed mix proportion chosen for the preparation of the specimens was 3:1 (Cement: Sand) with a water-cement ratio of 0.46 [13]. The cement was replaced by varying percentages of the human hair fiber (0%, 1%, 1.5%, and 2%) by weight, as shown in Table 1, and taken as the control mix was the plain cement fiberboard with 0% hair fiber.

Table 1: Designed mix proportion of each specimen

Cement: Sand	Water-Cement Ratio	Hair Fibre (By cement weight)
3:1	0.46	0%
2.97:1	0.46	1%
2.95:1	0.46	1.5%
2.94:1	0.46	2%

2. Procedure for the preparation of the specimens

a. Preparation of human hair fibres

The collected human hair fibers were washed with acetone to ensure the removal of unwanted particles and for polishing purposes. The hair fibers were air-dried for one day to remove the moisture. After air drying, the hair fibers were cut to the same length of 35mm to ensure uniform distribution.

b. Preparation of the specimens

The weight of each constituent for each specimen is in Tables 2 and 3 below. The cement and sand were thoroughly mixed for one minute at a dry temperature. Water and the required quantity of human hair fiber were also added, and the hair fiber should be distributed equally and thoroughly mixed until a uniform color was obtained. The mixture was poured into a mold. After 24 hours, the specimens

were removed from the molders and submerged in the water for 28 days for proper curing. Five samples were prepared for each treatment with different hair fiber percentages corresponding to 250 mm x 250 mm x 10 mm [13] for flexural strength, water absorption, bulk density, and fireproof test and specimens with sizes of 70x70x70mm for compressive strength testing.

Table 2: Weight of the constituents per specimen with the size of 250x250x10mm

Fibre %	Cement (g)	Sand (g)	Water (g)	Fiber (g)
0%	750	250	345	0
1%	742.5	250	345	7.5
1.5%	738.75	250	345	11.25
2%	735	250	345	15

Table 3: Weight of the constituents per specimen with the size of 70x70x70mm

Fibre %	Cement (g)	Sand (g)	Water (g)	Fiber (g)
0%	450	150	207	0
1%	445.5	150	207	4.5
1.5%	443.25	150	207	6.75
2%	441	150	207	9

D. Testing of cement fiber boards

All the specimens with different percentages of human hair fibers, such as 0%, 1%, 1.5%, and 2% per weight of cement, were tested to obtain the needed results. The sample's bulk density was determined using the water displacement method by measuring the volume of the mass of an example. The mechanical properties of concrete have a high impact when it comes to density. The fiberboard density will vary depending on the mixture used on each specimen. Water absorption provides preliminary quality-control information to determine whether water needs to be added or removed from the soil, and these were determined by testing the samples as per ASTM C1185. The conduction of the compression strength test was per ASTM D1037, and the results were measured using the standard compressive testing machine. A flexural strength test was also performed to measure the tensile strength of the CFB, and the results were determined using the universal testing machine as per ASTM C1185. The last test performed was the fire-proof capability, and the results were determined per the procedures given by ASTM E84.

III. RESULTS AND DISCUSSIONS

A. Water absorption test result

To evaluate the percentage of water absorbed by each specimen, water absorption per ASTM C1185 was conducted. Figure 2 shows the average water percentage absorbed by the samples with different hair fiber content after 24 hrs. The results of the

specimens range from 7.36% - 13.86%. The specimen with 2% of hair fiber has the highest percentage of water absorbed, which is 13.86%. The main reason for the increase in water absorption as the fiber content increases is due to the high capacity of the untreated natural fibers to absorb water [14,15], and this could create impurities and voids between the fiber and concrete, which will result in poor bonding caused by the low capacity of the concrete mixture and weak interfacial adhesion throughout the procedure. The presence of voids between the fibers and concrete caused the water to be trapped, increasing the specimens' composite weight. Therefore, the higher the percentage of hair fibers added to the sample, the higher the rate of water absorbed, which is also why each specimen's weight increased.

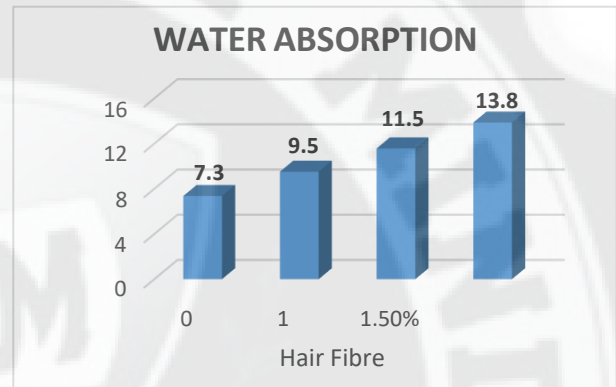


Fig. 2 Average result of water absorption with varying fiber percentage

B. Bulk density

Figure 3 shows the results of the specimen's density with varying percentages of hair fibers. The samples' density was evaluated after 28 curing days using the water displacement method. The results range from 1913.04 kg/m³ to 1647.06 kg/m³. The density of the samples is mainly influenced by their weight and especially by the mixture used on the specimens. CFB with 0% hair fiber has the highest result of density with 1913.04 kg/m³ since it is composed of 100% cement, while CFB with 2% hair fiber added to the mixture has the lowest value of density, which is 1647.04 kg/m³. The density of these samples decreased as the hair fiber increased because the more voids and impurities there were, the lower the sample density. This result is related to the compressive strength of the specimens because when the fiber content increases in the instance, the compressive strength also decreases.

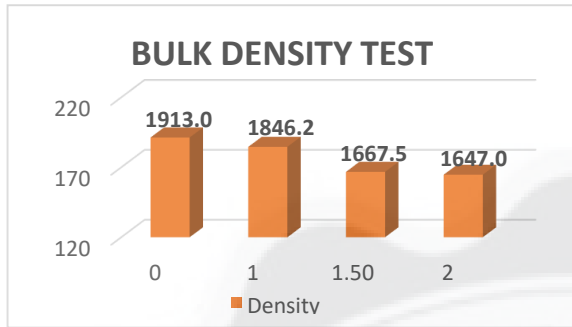


Fig. 3: Average results of bulk density with varying fibrepercentage.

C. Compressive strength test result

After 28 days, the specimens were tested by applying increasing compressive load until failure occurred as per ASTM D1037. The results are shown in Figure 4. Twenty (20) samples were prepared for the compressive strength test, five (5) specimens for each percentage of hair fiber. The bar graph shows the average value obtained from the compressive test result, which ranges from 11.53 – 15.638 N/mm^2 , while the error bars show the highest and lowest average value results of the specimen. CFB with 1.5% hair fiber has the highest average outcome value, while CFB with 2% fiber has the lowest mark. The results of the specimens with 1% and 1.5% human hair are much higher than the controlled mix sample, which is the CFB with 0% fibers and CFB with 2% hair fiber is lower than the controlled sample, which means adding hair fibers to the specimens contributes to increasing the compressive strength of the cement fiber board. However, the result decreased when the added hair fibers reached 2%. This only means that the compressive strength of the samples will fall if the addition of hair fiber in the mixture comes more than 1.5% hair fiber, and this is because the more fiber added to the specimen, the more voids are present in the mix. The overcrowding of the fibers has led to a reduction in binding between the cement and fibers, all of which have a massive effect on the material's compressive strength. Also, the natural fiber quality can only strengthen the tensile strength but not the compressive strength of the specimens [16]. On the other hand, the compressive average strength of the CFB with 1.5% fiber is 15.638 N/mm^2 which is the highest, is almost 42% less than the comparison material of 26.9 N/mm .

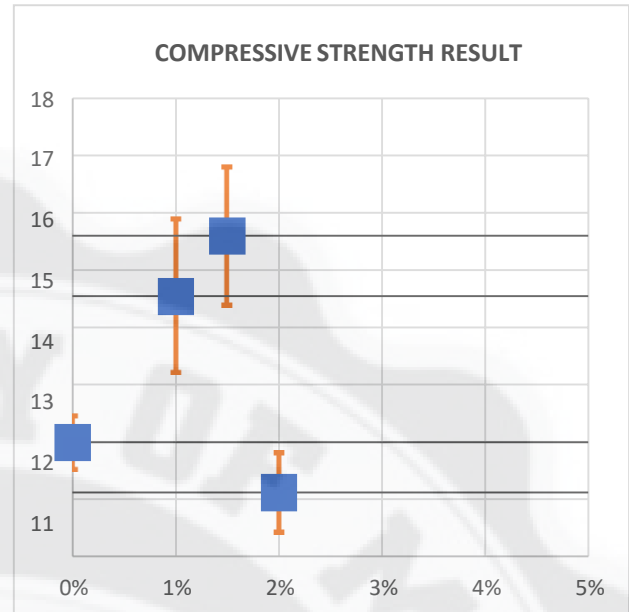


Fig. 4: Compressive strength results after 28 days

D. Flexural strength test result

Figure 5 shows the results obtained from the flexural strength test of the specimens with various percentages of human hair fiber. These specimens were tested after 28 days, and based on the results, CFB with human hair fibers gained higher flexural strength than the controlled mix samples (0%). The average value of the results is shown in the bar graph, which ranges from 4.92 MPa to 7.76 MPa, while the error bars show the specimen's highest and lowest average value results. CFB with 1.5% hair fiber has the highest average value of 7.76 MPa, while CFB with 0% hair fiber has the lowest average test result of 4.92 MPa. The increase in flexural strength of the specimens might be due to the addition of hair fibers since human hair fibers have a unique property of flexibility and high tensile strength.

Further expansion of the fiber reveals a decrease in the outcome of the specimens with 2% hair fiber. Visual observations during the concrete mixing revealed that the fibers turn spherical at 2% of human hair, making it challenging to separate them.

On the other hand, the flexural strength of the cement fiber board with human hair is much higher than the comparison material of 4.15 N/mm^2 according to ASTM C1185. CFB with 1.5% hair fiber has the highest average result, being almost 87% stronger than the comparison material of 4.15 N/mm^2 , proving that human hair fiber can be used as an alternative natural fiber for cement fiber board.

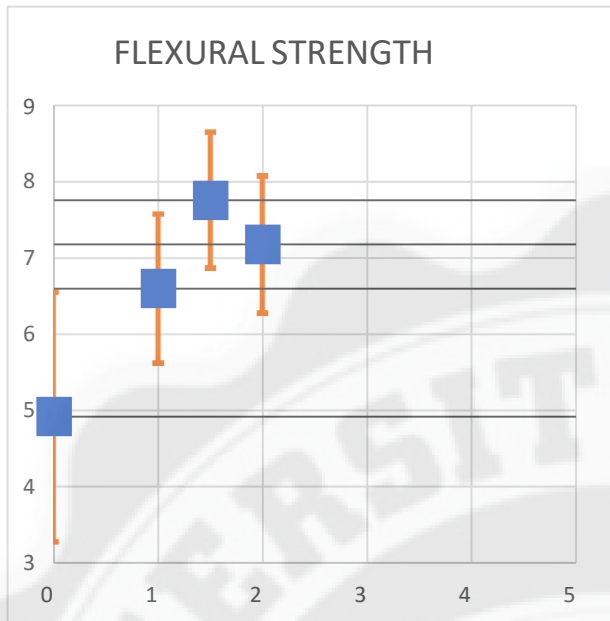


Fig. 5: Flexural strength results after 28 days

E. Fire proof capability

a. Comparison of the average weight between the unburnt and burnt samples after 60mins

Figure 5 shows the specimens' average weight after being exposed to a controlled environment burning process for about 60 minutes. The graph shows that the specimen's average weight decreased after burning the samples. The initial average weight of the specimens ranged from 1.43 kg to 1.46 kg, but after burning, the pieces lost approximately 100 grams of their weight. The weight lost in the cement fiber board is due to the conversion of the moisture present in the CFB to vapor, also called evaporation [17].

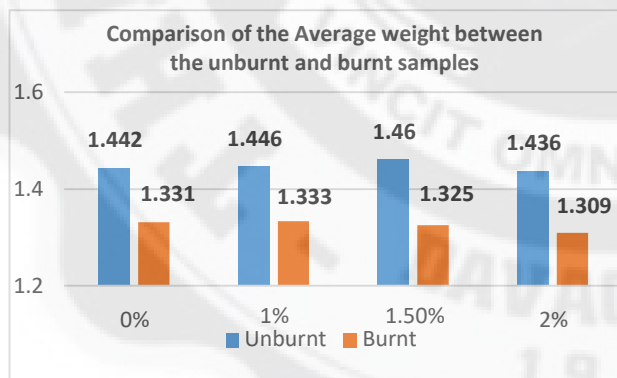


Fig. 6: Comparison of the average weight between the unburnt and burnt samples after 60mins

b. Visual observation of the cement fiber board after exposure to fire.

Figure 6 shows the specimens with different percentages of human hair fiber. A has 0% hair fiber, B has a content of 1% hair fiber by cement weight, C has a 1.5% of HHF, and D has the highest hair fiber content, which is 2%. These specimens with different percentages of human hair fiber were exposed to a controlled-environment burning process for about one hour. The figures show the behavior of the fiberboard after 60 minutes of fire exposure. The discoloration of the fiberboard observed above is only due to the smoke from the fire. The CFB with 0% of human hair fiber developed more hairline cracks than those CFB with 1%, 1.5%, and 2% of HHF. There was no shrinkage observed after the burning of the specimens. All of these observations are because of the main advantage of natural fibers in reducing the drying shrinkage and cracking of a cement fiber board [21].

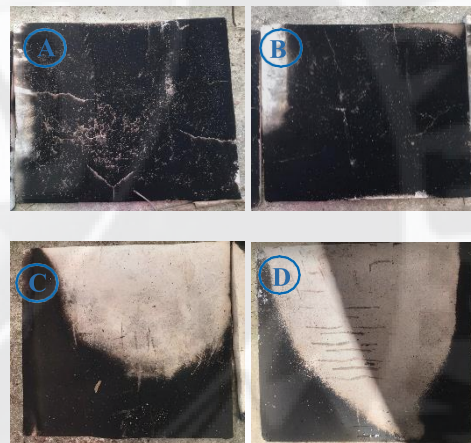


Fig. 7: Visual observation of the cement fiber board after exposure to fire

IV. CONCLUSIONS AND FUTURE WORKS

The researchers studied the effect of using human hair with a length of 35mm as a reinforcement in cement fiber board. Adding human hair can improve some but not all of the mechanical properties of the cement fiber board. Increasing the fiber content of the fiberboard has increased the specimens' water absorption and flexural strength with a dimension of 250x250x10mm, which passed the minimum strength of a cement fiber board according to ASTM C1185. Hair fibers also helped lessen the cracks formed in the specimens after fire exposure. However, the bulk density of the fiberboard decreased as the hair fiber increased, which affected the results of the compressive strength of the board. The results showed that the compressive strength of the board with a size of 70x70x70mm was increasing but still failed to meet the minimum strength of a CFB according to ASTM

D1037. Based on the results of each test, the researchers conclude that human hair fibers can only strengthen the flexural strength of the cement fiberboard, and the appropriate percentage of human hair fiber to develop a cement fiber board with human hair is 1.5%, with the strength increasing significantly in the compressive and flexural tests.

With the conclusion above, the researchers recommend conducting future work on cement fiber boards with human hair with the same parameters employed above but using treated human hair fibers with chemical treatment. A chemical treatment that can lessen the fiber's ability to absorb water [18, 19] and, by doing so, improve the compressive strength of the CFB. Also, to conduct more tests on the properties of the fiberboard to fully evaluate the effect of treated human hair fiber as a cement additive in cement fiber board.

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**Appendix A:
Research Data**

Bulk Density Result of the Cement Fibre Board with Human Hair

Bulk Density Test Result of the Cement fibre board			
Trial	Fibre Percentage	Mass	Volume
1	0%	1.27	0.79
2	0%	1.32	0.64
3	0%	1.26	0.62
4	0%	1.35	0.73
5	0%	1.40	0.67
	Average:	1.320	0.690
1	1%	1.27	0.77
2	1%	1.29	0.53
3	1%	1.46	0.84
4	1%	1.36	0.52
5	1%	1.285	0.95
	Average:	1.333	0.72
1	1.5%	1.29	0.86
2	1.5%	1.33	0.78
3	1.5%	1.26	0.74
4	1.5%	1.41	0.71
5	1.5%	1.33	0.88
	Average:	1.324	0.794
1	2%	1.35	0.88
2	2%	1.27	0.86
3	2%	1.41	0.76
4	2%	1.27	0.76
5	2%	1.42	0.82
	Average:	1.344	0.816

Formula:

New Water Level – Original Water Level = Volume of the Specimen

Original Level = 11L

Density = Mass/Volume

Average Test Results of Bulk Density

Fibre Percentage	New Water Level (L)	Average Volume (L)	Average Volume (m3)	Average Mass (kg)	Average Density (kg/m3)
0%	11.69	0.69	0.00069	1.320	1913.04
1%	11.72	0.72	0.00072	1.333	1846.26
1.5%	11.794	0.794	0.000794	1.324	1667.51
2%	11.816	0.816	0.000816	1.344	1647.06

Water Absorption Result of the Cement Fibre Board with Human Hair

Water Absorption Test Result of the Cement fibre board			
Trial	Fibre Percentage	Mass 1	Mass 2
1	0%	1428	1535
2	0%	1460	1560
3	0%	1440	1552
4	0%	1426	1530
5	0%	1446	1553
	Average:	1440	1546
1	1%	1450	1582
2	1%	1440	1571
3	1%	1468	1598
4	1%	1436	1578
5	1%	1438	1591
	Average:	1446.4	1584
1	1.5%	1476	1641
2	1.5%	1456	1623
3	1.5%	1436	1607
4	1.5%	1456	1628
5	1.5%	1446	1612
	Average:	1454	1622.2
1	2%	1434	1614
2	2%	1460	1664
3	2%	1434	1637
4	2%	1410	1617
5	2%	1440	1641
	Average:	1435.6	1634.6

Formula:

$$W = [(M2 - M1)/M1] \times 100$$

Where:

W = Water Absorption

M1 = Mass 1

M2 = Mass 2

Average Water Absorption Test Results

Fibre Percentage	Average Mass1(g)	Average Mass2 (g)	Water Absorption %
0%	1440	1546	7.36
1%	1446.4	1584	9.51
1.5%	1454	1622.2	11.57
2%	1435.6	1634.6	13.86

Flexural Strength Result of the Cement Fibre Board with Human Hair

Samples	0%	1%	1.5%	2%
S1	300	620	860	700
S2	620	740	840	630
S3	540	540	740	860
S4	340	620	800	740
S5	660	780	640	660

Formula:

Flexural Strength:

$$Fb = \frac{PL}{BD^2}$$

Where:

P = maximum load of every samples in N

L = length of the sample in mm

B = base of the sample in mm

D = depth of the sample in mm

Flexural Strength Test Result

Trial	Fibre Percentage	P	B	L	D	Fb (Mpa)
1	0%	300	250	250	10	3
2	0%	620	250	250	10	6.2
3	0%	540	250	250	10	5.4
4	0%	340	250	250	10	3.4
5	0%	660	250	250	10	6.6
						Average: 4.92
1	1%	620	250	250	10	6.2
2	1%	740	250	250	10	7.4
3	1%	540	250	250	10	5.4
4	1%	620	250	250	10	6.2
5	1%	780	250	250	10	7.8
						Average: 6.60
1	1.5%	860	250	250	10	8.6
2	1.5%	840	250	250	10	8.4
3	1.5%	740	250	250	10	7.4
4	1.5%	800	250	250	10	8.0
5	1.5%	640	250	250	10	6.4
						Average: 7.76
1	2%	700	250	250	10	7
2	2%	630	250	250	10	6.3
3	2%	860	250	250	10	8.6
4	2%	740	250	250	10	7.4
5	2%	660	250	250	10	6.6
						Average: 7.20

Compressive Strength Result of the Cement Fibre Board with Human Hair

Samples	0%	1%	1.5%	2%
S1	61.59	64.547	71.144	68.610
S2	60.28	69.305	72.202	53.587
S3	56.85	66.594	74.521	57.291
S4	56.20	75.519	86.446	52.360
S5	58.859	80.370	78.833	54.625

Formula to calculate compressive strength is

$$F_b = P/A$$

Where:

F_b = Compressive strength (MPa)

P = Maximum load (or load until failure) to the material (N)

A = Cross section of the area of the material resisting the load (mm²)

Compressive Strength Test Result

Trial	Fibre percentage	P	L	W	A	F _b (Mpa)
1	0%	61.59	70	70	4900	12.579
2	0%	60.28	70	70	4900	12.302
3	0%	56.85	70	70	4900	11.602
4	0%	56.20	70	70	4900	11.469
5	0%	58.859	70	70	4900	12.012
						Average: 11.991
1	1%	64.547	70	70	4900	13.173
2	1%	69.305	70	70	4900	14.144
3	1%	66.594	70	70	4900	13.591
4	1%	75.519	70	70	4900	15.41
5	1%	80.370	70	70	4900	16.402
						Average: 14.544
1	1.5%	71.144	70	70	4900	14.519
2	1.5%	72.202	70	70	4900	14.735
3	1.5%	74.521	70	70	4900	15.208
4	1.5%	86.446	70	70	4900	17.462
5	1.5%	78.833	70	70	4900	16.088
						Average: 15.638
1	2%	68.610	70	70	4900	11.961
2	2%	53.587	70	70	4900	10.936
3	2%	57.291	70	70	4900	11.692
4	2%	52.360	70	70	4900	10.685
5	2%	50.625	70	70	4900	10.337
						Average: 11.530

Fire Capability Result of the Cement Fibre Board with Human Hair

Mass of each unburnt specimens

Unburnt Samples (250mm x 250 mm x 10 mm) (kg)				
Trial	0%	1%	1.5%	2%
1	1.42 9	1.44 0	1.46 6	1.43 5
2	1.46 5	1.45 0	1.45 6	1.46 0
3	1.44 2	1.46 7	1.47 6	1.43 5
4	1.42 6	1.43 6	1.45 6	1.41 0
5	1.44 6	1.43 7	1.44 5	1.44 0
Average :	1.44 2	1.44 6	1.46 0	1.43 6

Mass of each burnt specimens

Burnt Samples (250mm x 250 mm x 10 mm) (kg)				
Trial	0%	1%	1.5%	2%
1	1.32 8	1.30 5	1.31 0	1.34 2
2	1.32 8	1.34 8	1.31 1	1.29 3
3	1.32 2	1.30 8	1.32 3	1.28 2
4	1.32 0	1.34 2	1.32 7	1.30 2
5	1.35 8	1.36 0	1.35 4	1.32 7
Average :	1.33 1	1.33 3	1.32 5	1.30 9

Appendix B: Documentations

Appendix B-1: Preparation of materials



Appendix B-2: Moulding and curing of the cement fibreboard samples



Appendix B-3: Testing of the cement fibreboard samples



Appendix C: Certificate of Appearance



College of Engineering Education
2nd Floor, B&E Building
Matina Campus, Davao City
Telefax: (082) 296-1084
Phone No.: (082)227-5456/305-0647 Local 133


CERTIFICATE OF APPEARANCE

TO WHOM IT MAY CONCERN:


THIS IS TO CERTIFY MARIA CRESILDA DELIMA, JHOANNA PATRICIA VANTA, AND ABBEYGAYL MARAVILLAS, UM Civil Engineering students researchers, personally appeared in the Civil Engineering Laboratory to conduct their testing on December 13-17, 2021 (1:00 pm to 5:00 pm).

This certification is issued upon request of the above-named person for whatever legal purpose it may serve.

Davao City, Davao Del Sur, July 14, 2023.


ENGR. RIVALDO P. SAHAGUN, JR.
CE laboratory Custodian

Appendix D: Research Documents

 UM The University of Mindanao	<h1>RESEARCH AND PUBLICATION CENTER</h1> <p><input checked="" type="checkbox"/> Main <input type="checkbox"/> Branch _____</p> <p>UNDERGRADUATE RESEARCH AGREEMENT</p>
<p>As a research student, I hereby declare my acceptance and adherence to the policies, rules, and guidelines in the conduct of my thesis/capstone/FS/creative work as follows:</p> <ol style="list-style-type: none">1. The researcher/s shall be required to attend the research orientation and shall submit this signed agreement to the subject teacher. Failure to do so shall render the researcher/s ineligible for title defense.2. The researcher/s shall group themselves by three, of their own choice and at their own risk. They shall work as a team from the initiation to completion of the project. They shall choose a research topic/theme/subject that is aligned with the agenda of the College and the University.3. With advisement from the Research Coordinator(RC) and approval of the Dean of College, the researcher/s shall be provided with qualified research personnel (adviser and statistician) to help them out in the conduct of the project.4. The researcher/s shall exercise due diligence and adhere to established standards/rules of data gathering, experimentation, field work that ensure safety, security and ethical practice. Research activities in remote and secluded areas are highly prohibited.5. The researcher/s shall seek guidance, assistance and approval from their adviser in all research-related activities, documented in a journal/record book which is to be inspected by the subject teacher from time to time for purposes of monitoring.6. The researcher/s shall always secure the endorsement of the adviser before submitting the outline/final manuscripts for defense to the RC.7. The researcher/s shall be responsible to get updates about schedules for outline/final defense (one month before finals) and on thesis binding as announced/posted. Two (2) copies of the outlines/manuscripts shall be submitted to the RC one week before the scheduled defense.8. The researcher/s shall pay P2700 per group as defense fee. Lone-research or two-member group are allowed only when there is no other possible way to divide the class. Anything beyond, needs to obtain RPC consent through writing. No additional payment shall be made to panel members. Researcher/s are strongly enjoined to report to the Dean/RPC any extra fee solicited by any party.9. The researcher/s shall deliver oral defense as scheduled by the RC before the final exam. Failure to submit themselves for oral examination forfeits their right to obtain a passing grade. Likewise, failure to submit bounded duly approved final manuscript on time shall cause a grade of 7.2 which should be completed within the standard completion days as prescribed by the UM registrar. No extension shall be entertained.10. In the event that the researcher/s failed to meet and/or satisfy the requirements and criteria for title, outline and final defenses, they shall be given another chance through redefense. This redefense is granted only once. Should the researcher/s failed during the redefense, they shall be given a failing grade and are required to reenroll the course.11. The researcher/s shall bring all the raw data and evidences of data gathering procedures during the oral defense as indicator of data trustworthiness and reliability.12. All transactions with research personnel during the processing/critiquing of the final manuscript shall require the use of the standard routing form. This routing form is to be submitted to the RC for documentation and future reference.	



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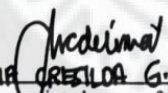
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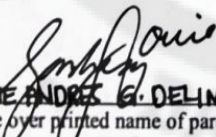
13. The researcher/s shall maintain the right for three (3) free plagiarism checks: one during Methods of Research or its equivalent, and two during Research Proper after final oral presentation. Five hundred pesos shall be charged for the fourth and succeeding checks. Threshold of similarity is 25% and lower.
14. Manuscripts shall follow the institutional format and referencing style; the study must be a product of exercise of intellect, free of dishonesty and fraud. Also, the papers shall be subjected for Grammarly check to ensure adherence to rules of language and writing conventions. Threshold of grammar accuracy is 95% and above.
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18. The researcher/s shall present their research projects strictly during their scheduled oral defense. Failure to present as scheduled, the researcher/s will have to wait for another cycle of defense.

I affix my signature to signify that I read, understand, and conform to the items enumerated above.

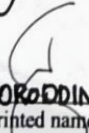
Conformed:



MARIA GRELLA G. DELIMA
Signature over printed name of student



LOUIE ANDRES G. DELIMA
Signature over printed name of parent/guardian



ENGR. NORODDIN V. MELEG
Signature over printed name of adviser



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UNDERGRADUATE RESEARCH AGREEMENT

As a research student, I hereby declare my acceptance and adherence to the policies, rules, and guidelines in the conduct of my thesis/capstone/FS/creative work as follows:

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I affix my signature to signify that I read, understand, and conform to the items enumerated above.

Conformed:

Joanna Patricia Vanta
Signature over printed name of student

Mary Judith C. Vanta
Signature over printed name of parent/guardian

ENGR. NORDDIN V. MEOG
Signature over printed name of adviser



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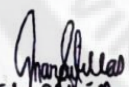
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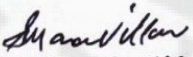
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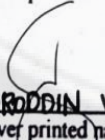
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I affix my signature to signify that I read, understand, and conform to the items enumerated above.

Conformed:


ARREY GARCIA M. MARRAVILLAS
Signature over printed name of student


SYLVIA M. MARRAVILLAS
Signature over printed name of parent/guardian


ENGR. NORODDIN V. MELOS
Signature over printed name of adviser

October 5, 2020

ENGR. NORODDIN V. MELOG
Faculty Member, BSCE Program
College of Engineering Education

Dear **Engr. Melog**:


Greetings!

I am pleased to appoint you as the adviser of **Maria Cresilda G. Delima, Jhoanna Patricia C. Vanta, Abbey Gayl M. Maravillas** of the undergraduate thesis entitled **Use of human hair as a reinforcement in cement fiberboard** of the Bachelor of Science in Civil Engineering program of the College of Engineering Education. This appointment is in reference to your field of specialization and your qualification as a thesis adviser reflected in OPM 14.03 (Conduct of Undergraduate Thesis).

Please affix your signature hereunder to signify your acceptance of the appointment. Looking forward to your continued support in the research endeavor of the college.

Thank you, and have a nice day ahead!

Sincerely yours,



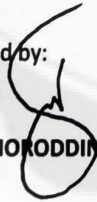
JETRON VADTOON
College Research Coordinator

Noted:



Dr. CHARLITO L. CAÑESARES
Dean of College

Accepted by:



ENGR. NORODDIN V. MELOG

October 5, 2020

ENGR. STEPHEN PAUL ALAGAO
Faculty Member, BSCpE Program
College of Engineering Education

Dear **Engr. Alagao**:


Greetings!

I am pleased to appoint you as the adviser of **Maria Cresilda G. Delima, Jhoanna Patricia C. Vanta, Abbey Gayl M. Maravillas** of the undergraduate thesis entitled **Use of human hair as a reinforcement in cement fiberboard** of the Bachelor of Science in Civil Engineering program of the College of Engineering Education. This appointment is in reference to your field of specialization and your qualification as a thesis adviser reflected in OPM 14.03 (Conduct of Undergraduate Thesis).

Please affix your signature hereunder to signify your acceptance of the appointment. Looking forward to your continued support in the research endeavor of the college.

Thank you, and have a nice day ahead!

Sincerely yours,




JETRON ADTOON
College Research Coordinator

Noted:



Dr. CHARLITO CAÑESARES
Dean of College

Accepted by:



ENGR. STEPHEN PAUL ALAGAO



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Course Code: 05189

Program: BSCPE

This is to acknowledge acceptance of assignment as Research Personnel for the thesis entitled:

Use of human hair as reinforcement in a cement fiberboard

	Name	Signature	Date
Adviser	<u>Engr. Noroddin V. Melog</u>	<u>[Signature]</u>	<u>10-05-20</u>
Statistician/Data Analyst	<u>Engr. Stephen Paul Alagao</u>	<u>[Signature]</u>	<u>10-05-20</u>
Editor	_____	_____	_____
Panel Members	<u>Engr. Jetrap Adtoon</u>	<u>[Signature]</u>	<u>10-05-20</u>
	<u>Engr. Michelle Darrol</u>	<u>[Signature]</u>	<u>10-05-20</u>

Endorsed by: Engr. Jetrap Adtoon
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Dean of College

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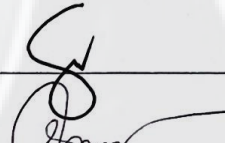
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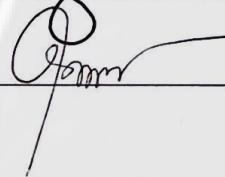
This is to endorse the research manuscript entitled: **“Use of human hair as a reinforcement in cement fiberboard”** prepared and submitted by **Maria Cresilda G. Delima, Abbey Gayl M. Maravillas , and Jhoanna Patricia C. Vanta** for Final Defense. The manuscript has been evaluated by the research personnel listed below and was found to be compliant with the quality standards as provided in the UM Research Manual.

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Adviser **Engr. Noroddin V. Melog**





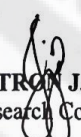
Statistician **Engr. Stephen Paul Alagao**

Endorsed by:




ENGR. NORODDIN V. MELOG
Research Adviser

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College Research Coordinator

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
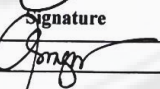
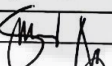

Title : Use of human hair fiber as a reinforcement in cement fiber board

Student-Proponents	Program
1. Maria Cresilda G. Delima	BSCE
2. Jhoanna Patricia C. Vanta	BSCE
3. Abbey Gayl M. Maravillas	BSCE

Panel Comments/ Recommendations	Previous Status	Actions Taken / Revisions	Page Reflected
Improve or change the title of the study	The title was cement fiber board with human hair as a concrete additive	The title was improved	1
Discussion of the results should be placed before the figures or graph.	The figures and graphs were presented first before the results were discussed.	The results were discussed first and placed the figures and graph after the discussions.	3-5
Present the results of compressive and flexural strength test by using bar graph with error bar graphs.	Bar graphs were only used to present the results of the particular tests.	Bar graphs with error bar were used in the presenting the results of compressive and flexural strength test.	3-4
The specimen's dimensions and the length of hair fiber used should be mentioned in the conclusion.	The length of the fiber and dimensions of the samples were not mentioned in the conclusion.	The dimensions and length were already mentioned in the conclusion.	6
Improve the significance of the study	The significance mentioned in the paper was intended for RRL of the study.	The significance of the study was improved.	1-2
The description of the figures in results E1 should be presented clearly and present only 4 images of the specimens.	The description of the figure were not clearly stated and there are a lot of images were presented.	The description of the figure were clearly stated and other unnecessary images were removed.	5-6
Observe the IEEE format for the references.	Two of the references mentioned did not follow the format.	The references already followed the given IEEE format	6

*You may add more columns if necessary

APPROVALS:

C NC	Complied Not Complied	Thesis Adviser / Editor	Signature	Date
	C	Engr. Noroddin V. Melog		7/11/23
C NC	Complied Not Complied	Statistician	Signature	Date
	C	Engr. Stephen Paul Alagao		7/11/23
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	C	Engr. Michelle A. Daarol		7/11/23
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Maria Cresilda G. Delima, Abbey Gayl Maravillas, Jhoanna Patricia Vanta

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Use of human hair fiber as a reinforcement in cement fiber board

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Abstract. Waste materials like human hair are abundant everywhere and produced in large quantities that cannot be recycled. This waste is responsible for flooding sewage lines and polluting the environment. However, not all types of human hair can be recycled. To increase the strength of human hair, a study was conducted to determine the effect of human hair fiber as a reinforcement in cement fiberboard and its relation to other fibers, particularly on bulk density, water absorption, compressive strength, flexural strength, and creep resistance. After 28 days of curing, the 100% human hair fiber reinforced concrete samples with a design mix ratio of 1:1 cement sand to have concrete were replaced by human hair fibers by weight percentage of 0%, 1.5%, and 2%, and plain concrete with 0% human hair fiber as the control specimen. Based on the results, adding human hair fiber to a cement fiber board can improve some of the mechanical properties. The human hair fiber reinforced concrete samples showed higher flexural strength and compressive strength compared to the control specimen. The addition of human hair fiber also resulted in a decrease in water absorption and an increase in creep resistance, which proved that these fibers could be used as a viable alternative material for concrete fiberboard and other related human hair waste.

Keywords: Cement fiber board (CFB), Human hair fiber (HHF), human, Fresh Concrete

1. Introduction

The Philippines has a population of approximately 113 million, and this number of people will continue to produce waste material like hair, such as scalp, beard, and body hair. These wastes can be treated environmentally friendly and harmless to people's health when they get the proper amount of hair care products which help to condition the hair fibers which increase their length [1]. Human hair waste is found in abundance in everyday life. These wastes are produced in large quantities and estimated to be 6.9 x 10¹⁰ tonnes each year [2] and cannot be easily recycled, which end up in the streets or drainage systems in the community, where it will take several years to decompose [3]. With a population of approximately 270,000 (Davao City) in the number one spot, Mind in Mindanao, which has approximately 1,000,000 people, and the third City has a population of 2,000,000, which is Cebu. The fourth is Iloilo City, which has 1,250,000 people. These significant cities produce human hair waste daily.

Human hair has been effectively used as a fiber by various researchers because it is the most affordable and

environmentally friendly type of fibers that has been used as reinforcement since the earliest days [4]. Hair fibers are formed by a protein also known as keratin, which gives the hair flexibility, strength, and durability [5]. This kind of fiber became an effective reinforcement material due to its compressive strength, which enhanced the performance of concrete and reduced environmental problems, and decrease strength of these fibers was similar to the strength of a copper wire with the same diameter [6]. Hair fibers were used as a secondary reinforcement to prevent the concrete from splitting or control cracking and plastic shrinkage [7]. Also, the authors work also considered a conditioning agent and with the specific length and diameter, these fibers were used to strengthen the work and improve the work's ductility [8].

Cellulose fibers are the key ingredients for concrete fiberboard and cellulose fibers can be produced in plants, wood, and vegetables [9]. Strong fibers, basic, natural conditioning and processes can affect the size and quality of human hair which results in a large problem in conditioning cellulose fibers [10]. For this reason, this will have a large impact on the human hair industry where the country is now a progressive country. In the near future, if all these wastes were recycled, it would be a good idea to use of naturally occurring materials, making it environmentally for structural purposes. There can be used to control the hairline crack and prevent the developing in concrete as a result of plastic and drying shrinkage [11] and to reduce the water permeability and bleeding water. Fibers like polypropylene fibers, nylon fibers, natural fibers, glass fibers, and carbon fibers have been used to enhance concrete strength and reduce plastic shrinkage [12]. For this reason, human hair can be a large alternative to cellulose fibers by utilizing human hair that is only waste and make it useful, that is why human hair fibers have been used in this study as a natural source of reinforcement.

The main objective of this research is to study the utilization of human hair fiber as a concrete additive to develop a cement fiber board with natural fibers. Specifically, to evaluate the effect of human hair fiber as a reinforcement of the concrete fiber board, particularly with bulk density, water absorption, flexural strength, compressive strength and especially with the flexural strength.

This study benefits both the construction industry and the environment. Using human hair as a concrete fiberboard could help the construction industry's search for affordable and green building materials that can be used in the future and at

Use of human hair fiber as a reinforcement in cemen fiber board

by NORODDIN V MELOG

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CERTIFICATION

This is to certify that the undergraduate thesis output of Maria Cresilda G. Delima, Jhoanna Patricia C. Vanta and Abbey Gayl M. Maravillas entitled “**Use of human hair fiber as a reinforcement in cement fiberboard**” in partial fulfillment of the requirements for the Degree of Bachelor of Science in Civil Engineering has been properly reviewed to be aligned with the set of structural rules govern that the composition of sentences, phrases and words in English Language.

Sincerely yours,



ENGR. NORODDIN V. MELOG

Grammarian


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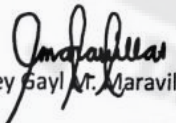
AUTHORIZATION LETTER

This is to authorize the University of Mindanao and adviser/co-author, **ENGR. NORODDIN V. MELOG** of the study entitled **USE OF HUMAN HAIR FIBER AS A REINFORCEMENT IN CEMENT FIBERBOARD** to present the paper in local, national or international research conferences; publish the paper in local, national or international research journals; and/or submit the paper for national or international intellectual property protection. It is therefore the responsibility of the adviser to ensure that the primary authors/inventors/makers/designers are given due recognition.

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