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The study of the effect of the variation of percentages of fibers in the gradients of composite materials on the percentage of moisture absorption of concrete beams for water

Mohammed Babiker Ahmed Babiker, Salaheldin M. Elarabi

Faculty of Industries engineering and Technology, University of Gezira

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ABSTRACT

Composite materials are used to reinforce concrete beams so that their properties become better in regard of breaking and stress strengths. This will decrease building faults rising when using traditional building materials. Wood, for example, suffers from low strength when attacked by insects and fungi. Steel, on the other hand, suffers from corrosion in wet weathers where it decays easily and quickly. This study aims to reduce faults of buildings by using kenaf and steel reinforced composites instead of the normal traditional building materials. Three samples A, B, and C were prepared with ratios of 70%:30%; 50%:50%; and 30%:70% of kenaf to steel fiber ratio as reinforcement materials to an epoxy polymer. The samples were used to replace 20%, by weight, of cement that is used in manufacturing concrete beams. The fabrication process was done in a standard mold of dimensions of 15×15×52.5 cubic centimeter. The components were well stirred to ensure a homogeneous mixture, left for 24 hours at room temperature, then removed and taken to a water container for wetting for 7 days and 28 days respectively for each sample including the standard sample. The samples were removed and tested for moisture content and moisture regain. The results showing that, the percentage of water absorption of standard sample after 7days is 0.52% , So the best sample B with percentage of water absorption is 1.15% and then C with percentage of water absorption is 1.78 and A with percentage of water absorption is 2.96% . As the result showing that the percentage of water absorption of standard sample after 28 day is 1.94%, So the best sample B with percentage of water absorption is 1.72%, Then C with percentage of water absorption is 3.25 and A with percentage of water absorption is 6.36%

Key words: composite materials, concrete beams, kenaf fibers, steel fibers, epoxy, moisture content and moisture regain.

1. Introduction

The traditional uses of kenaf fiber are in manufacture of rope, twine, coarse cloth, and the production of paper, bags, felt, insulations, geotextile, agro-textile, automotive, panels, wood substitution.

Combining kenaf fibers with other resources provides approach for producing advanced composite materials that take advantage of properties of both types of resources. It allows the scientist to design materials based on the end user requirements. Within a frame work of cost, energy use, accessibility, recyclability and environmental considerations. Kenaf fibers are potentially exceptional reinforcing filler in thermosetting composites. Results indicate that kenaf fibers are a viable option to inorganic mineral-based reinforcing fibers as long as the right processing conditions and aid are used, and for applications where the higher water absorption of the fibers composite is not serious. (Arjmandi, Yıldırım et al. 2021)

Kenaf fiber reinforced composites have been gaining a wide use in diversity of applications. It could be utilized as reinforcement material for polymeric composites as substitute of glass fiber. It provides high inflexibility and strength values. They also have higher aspect ratios making them suitable to be used as reinforcement in polymer composites. The gorgeous skin of kenaf fibers are the low cost, light weight, renewability, biodegradability, and high specific mechanical properties, no smell, color, fiber easy extraction, and short process. kenaf fiber has superior flexural strength and brilliant tensile strength which make kenaf a good candidate for many applications such as automotive, that also makes it the material of choice for a wide range of extruded, molded and non-woven products. (Arjmandi, Yıldırım et al. 2021)

2.Material and methods:

2.1 Materials:

Kenaf fibers were used as a source of fibers reinforcements for this research work. These fibers were cut by scissors and prepared to fit the fabrication technique of the composite as shown in Figure 1. A mold was used to preparing the composites materials that contain kenaf fibers, epoxy adhesive and metallic particles. Parallel rectangular molds have been used to fabricate the composite materials.



Figure 1: preparation of fibers

The physical properties of kenaf fibers are shown in Table 1 below.

Table 1: physical properties of kenaf fibers

NO	Properties	Typical Values
1	Length	1.5-2.6 cm
2	Diameter	25-75 micron
3	Color	White inclined to yellow
4	Cellulose %	44 – 57
5	Hemi cellulose %	21 – 23
6	Lignin %	8-13
7	Density	1.2 – 1.5 g / cm3
8	Water Absorption %	8 – 18
9	Tensile Strength	223 – 930 MPa
10	Young s Modulus	14 – 73 GPa
11	Elongation %	12 – 15
12	Flexural Strength	50 – 120 MPa
13	Flexural Modulus	1.5 – 6.5 GPa

The physical properties of metallic particles vary depending on the type of metal and its form (e.g., nano, micro, or bulk particles), but generally the followings are the key characteristics:

Table 2: physical properties of metallic particles

No.	Property	Description
1	Density	High density (7.87 g/cm3)
2	Particle size& shape	Ranges from nanometers to micrometers; shape affects surface area and reactivity
3	Color	Reddish brown
4	Melting point	High melting point
5	Thermal conductivity	Excellent conductors of heat
6	Electrical conductivity	Excellent conductors of electricity
7	Magnetic properties	Ferromagnetic
8	Surface Area	Inversely proportional to particle size; nano particles have high surface area
9	Hardness	Varies; often harder at smaller scales due to grain size effects.
10	Luster	Metallic shine due to free electrons

2.2 Methods:

2.2.1 Composites fabrication:

2.2.1.1 Improvement the absorbency of kenaf fibers

Kenaf fibers have been immersed in caustic soda concentrically 2% for 45 minutes at 70c. these fibers are washed with hot water for 5minutes and then these fibers are washed with water and soap at 80c for 5minutes.finally the fibers are washed with water and soap at room temperature.

2.2.1.2 The process of manufacturing of composites materials

The fiber, epoxy resin and metallic particles have been weighted and mixed together in different ratios for preparing the composites laminates.

The molds have been prepared by using film to prevent the adhesion the composites with the mold, the mold have dimensions 30cmx10cmx2cm.



Figure 2: preparation of the composites laminates

The fiber, epoxy resin and metallic particles have been mixed together in different ratios by using metallic tool for preparing the composites laminates. These laminates were let for drying at room temperature for 10 hours.





Figure 3: epoxy resin and hardener epoxy

2.3 Manufacture of concrete beams

2.3.1 Standard sample

Concrete was prepared with a weight of 21164g, washed well, and then poured into the mixing bowl. The sand was prepared with a weight of 9336g, cleaned well, and then poured into the mixing bowl. The cement was prepared with a weight of 3300g, then it was poured into the mixing bowl, and the ingredients were mixed well and water was added to it until it became well mixed by hand. The molds were equipped with dimensions of 15cm x 15cm x 52.5cm. The molds were wiped with hydraulic oil to facilitate the extraction of concrete beams from the molds after they had dried. The weights of the ingredients are shown in table 1 below.

Table 3: composition of the standard sample

Ingredients	Concrete	Sand	Cement
Weight (gm)	21164	9336	3300

Figures 1 and 2 show the preparation of the standard sample. The components of the concrete mixture were poured into the mold in three stages, with pressure being applied with a metal tool after each stage. The concrete was left in the molds to dry for 24 hours, and then the concrete was extracted from the molds and immersed in plastic basins containing water. After 7 days of immersion, preliminary tests were conducted, and after 28 days of immersion, final tests were conducted.







Figure 4: mold parts









Figure 5: preparing and mixing the concrete components









Figure 6: manufacturing of concrete beams

2.3.2 Samples:

The fiber, epoxy resin and metallic particles have been mixed together in different ratios by using metallic tool for preparing the composites laminates. These laminates are left for drying at room temperature for 10 hours. These samples are shown in Table 3.**Table 4: samples and weight characteristics**

Samples	Weight (gm)			
	Kenaf fibers	Metallic particles	Epoxy + hardener	Laminate
A (70%&30%)	21	9	630	660
B (50%&50%)	15	15	630	660
C (30%&70%)	9	21	630	660

For the samples, A, B, and C, concrete was prepared with a weight of 21164g, washed well, and then poured into the mixing bowl. The sand was prepared with a weight of 9336g, cleaned well, and then poured into the mixing bowl. The cement was prepared with a weight of 2640g. Then these components were poured into the mixing bowl, mixed well and water was added to ensure a well-mixed material. The mixture was poured in the mold in three equal amounts. The composite material(laminate) is placed after the first amount and then completed by the second and third amount, being well mixed after adding each amount. A pressure was applied with

a metal tool after each amount being added. The mixture was left in the molds to dry for 24 hours, then extracted and immersed in plastic basins containing water. After 7 days of immersion, preliminary tests were conducted, and after 28 days of immersion, final tests were conducted. The ingredients were shown in table 4 below.

Table 5: the components of the composite materials

Ingredients	Concrete	Sand	Cement	Laminate
Weight / g	**21164**	**9336**	**2640**	**660**

3. Results and discussions:

3.1 The results of moisture contents

The equation of moisture content = wet weight –dry weight / dry weight x 100

Table 6: The moisture content of standard beam of zero fibers

(Sample S)

Beam	7days			28days		
	Wet weight/ kg	**Dry Weight /kg**	**Absorpt-ion %**	**Wet weight/ kg**	**Dry weig ht/kg**	**Absorpt -ion %**
1	33945	33800	0.42	34950	33800	3.29
2	33980	33800	0.52	34990	33800	3.40
3	34056	33800	0.75	34130	33800	0.97
4	34012	33800	0.62	34190	33800	1.14
5	33890	33800	0.27	34020	33800	0.65
The average	**33977**	**33800**	**0.52**	**34456**	**33800**	**1.94**

Table 7:The moisture content of 70% kenaf +30% metallic particles fibers

(Sample A)

Beam	7 days			28 days		
	Wet weig ht/kg	**Dry weight/ kg**	**Absorpt -ion%**	**Wet weight/ kg**	**Dry weight/ kg**	**Absorpt -ion%**
1	34807	33802	2.97	35954	33801	6.37
2	34798	33796	2.96	35948	33797	6.36
3	34812	33798	3.00	35959	33803	6.38
4	34791	33794	2.95	35945	33794	6.37
5	34792	33810	2.90	35944	33805	6.33
The average	**34800**	**33800**	**2.96**	**35950**	**33800**	**6.36**

As shown in the above table, it is clear that sample A has the highest value of moisture content percents when let in water for 28 days. This is because of the high ratio of the kenaf fibre in the laminated composite.

Beam	7 days			28 days		
	Wet weight/ kg	**Dry weight/ kg**	**Absorpt -ion%**	**Wet weight/ kg**	**Dry weight/ kg**	**Absorpt -ion%**
1	34188	33800	1.15	34381	33798	1.72
2	34190	33799	1.16	34380	33800	1.72
3	34194	33797	1.17	34385	33800	1.73
4	34189	33802	1.14	34377	33803	1.70
5	34189	33802	1.14	34377	33799	1.71
The average	**34190**	**33800**	**1.15**	**34380**	**33800**	**1.72**

Table 8: The moisture content of 50% kenaf +50% metallic particles fibers

(Sample B)

For sample B has the lowest value of moisture content percents when let in water for 28 days. This is because of the balance between ratio of kenaf fibers and metallic fibers in the laminated composite.

Table 9: The moisture content of 30% kenaf +70% metallic particles fibers

(Sample C)

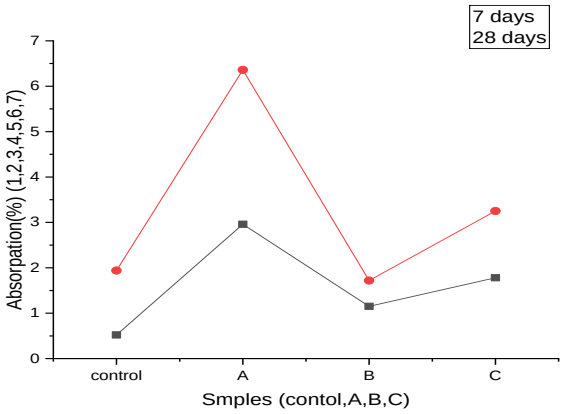
Beam	7 days			28 days		
	Wet weight kg	**Dry weigh t/kg**	**Absorpt-ion %**	**Wet weight/ kg**	**Dry Weight /kg**	**Absorpt-ion%**
1	34402	33801	1.78	34898	33801	3.25
2	34400	33802	1.77	34896	33800	3.24
3	34401	33800	1.78	34901	33803	3.25
4	34397	33800	1.78	34904	33798	3.27
5	34400	33797	1.78	34901	33798	3.26
The average	**34400**	**33800**	**1.78**	**34900**	**33800**	**3.25**

For sample C has the highest value of moisture content percents when let in water for 28 days. This is because of the high ratio of the metallic fibre in the laminated composite.

Table 10: Comparison of average value of moisture content for samples

Sample	Average Values	
	7 Days	28 Days
Control	0.52	1.94
A	2.96	6.36
B	1.15	1.72
C	1.78	3.25

As shown in table 10 , samples A &C have highest values of moisture content whether in 7 days or 28 days. This is when compared to sample B, which shows low value for both the 7 &28 days .This it has the nearest values of moisture content to the control sample.



4. Conclusion

The study were concluded that use of a composite materials from kenaf fibers& metallic fibers of samples (A,B,C) the percentage (70%&30% " 50&,50% " 30%&70%) sequentially with the epoxy resin as connection material with hardener materials , Whereas the composite materials are used by 20% percentage from the weight of the cement entire in the ingredient of concrete beams , were improved percentage of moisture absorption of concrete beams with very good percentage as compared with the standard concrete beam. Also the study were concluded that the best sample (B ,C, and A) sequentially.

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