POLİTEKNİK DERGİSİ

JOURNAL of POLYTECHNIC

ISSN: 1302-0900 (PRINT), ISSN: 2147-9429 (ONLINE)
URL: http://dergipark.org.tr/politeknik

The investigation of mechanical properties of polypropylene fiber-reinforced composites produced with the use of alternative wastes

Alternatif atıkların kullanımı ile üretilen polipropilen lif takviyeli kompozitlerin mekanik özelliklerinin araştırılması

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Bu makaleye şu şekilde atıfta bulunabilirsiniz(To cite to this article): Külekçi G., ve Çullu M., "The investigation of mechanical properties of polypropylene fiber-reinforced composites produced with the use of alternative wastes", ***Politeknik Dergisi***, 24(3): 1171-1180, (2021).

Erişim linki (To link to this article): http://dergipark.org.tr/politeknik/archive

DOI: 10.2339/politeknik.777832

The Investigation of Mechanical Properties of Polypropylene Fiber-Reinforced Composites Produced With the Use of Alternative Wastes

Highlights

- *Using copper mine tailing, marble waste and fly ash as aggregate.*
- *The synthetic fibers used in the composite material increased the Tensile test.*
- *The increase in fiber ratio decreased the compressive strength and increased the tensile strength*
- *Better mechanical properties were obtained compared to fly ash in the use of copper mine tailings and marble powder as aggregates.*

Graphical Abstract

Beam samples were poured with the dimensions of by adding polypropylene fiber to the mixture obtained by using solid wastes; its effects on mechanical properties were conducted.

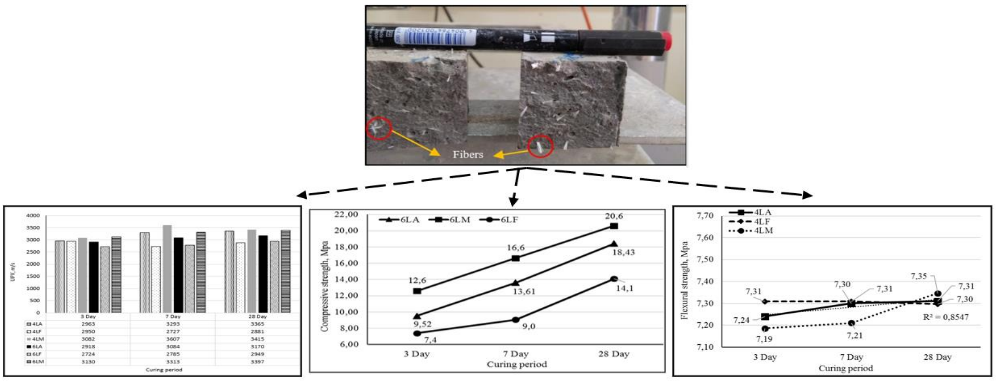

Figure. Ultrasonic impact velocity test, bending test and compressive strength tests were carried out on 40 × 40 × 160 mm sized beam samples containing fibers.

Aim

The aim of this study is to increase the use of mine tailings instead of aggregate in Composite and to reveal the usability of the amount of synthetic fiber with tailings.

Design & Methodology

Beam samples with the dimensions of 4x4x16 cm were prepared to determine the tensile strength and toughness values. Samples remaining after the tensile strength test were cut into the parts with the dimensions of 4x4x8 cm and subjected to a compressive strength test.

Originality

In most of the studies in the literature, fibers are used with aggregate, very few of them have used mine tailing instead of aggregate. In this study, mineral waste was used instead of aggregate in Composite, which is scarce in the literature, and bending tests were carried out by adding fiber to the resulting mixture.

Findings

According to the findings of the study, the amount of fiber was found to be directly proportional with the tensile strength, and the tensile strength increased as the amount of fiber increased; also, the tensile strength was found to be correlated with dehydration and waste type. It was concluded that the amount of fiber did not have a significant effect on the uniaxial compressive strength.

Conclusion

As a result of the study, it has been revealed that mineral wastes can be used instead of aggregate in Composite and the amount of fiber added to the mixture has an important effect on tensile strength

Declaration of Ethical Standards

The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

The Investigation of Mechanical Properties of Polypropylene Fiber-Reinforced Composites Produced With the Use of Alternative Wastes

(A part of this article was presented as an oral presentation at the 3rd International Conference on Advanced Engineering Technologies (ICADET'19) held by Bayburt University on September 19-21, 2019)

Araştırma Makalesi / Research Article

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(Geliş/Received : 07.08.2020 ; Kabul/Accepted : 18.01.2021 ; Erken Görünüm/Early View : 25.01.2021)

ABSTRACT

Various studies on the disposal or storage of the wastes generated due to mining activities have been carried out until today. With the developing technology, the use of alternative products instead of aggregates in Composite and the effect of fiber addition were investigated. The most common of these studies is the bending strength tests on the beam sample. In this study, solid wastes generated by mining operations were used instead of aggregate used in Composite. Beam samples were poured with the dimensions of 40×40×160 mm by adding 4-6 kg/m3 polypropylene fiber to the mixture obtained by using these solid wastes; then, its effects on ultrasonic pulse velocity test, tensile test, and compressive strength tests were conducted. According to the results of these tests, it was found that the fibers had a positive effect on compressive strength and bending strength. Also, it was found that water absorption rates and densities did not have an effect, while the ultrasonic pulse velocity decreased with increasing fiber content.

Keywords: Tensile strength, mine tailings, composite backfill, synthetic fiber, tailings.

Alternatif Atıkların Kullanımı ile Üretilen Polipropilen Lif Takviyeli Kompozitlerin Mekanik Özelliklerinin Araştırılması

ÖZ

Madencilik faaliyetleri nedeniyle oluşan atıkların bertaraftı veya depolanması konusunda bugüne kadar çeşitli çalışmalar yapılmıştır. Gelişen teknoloji ile betonda agrega yerine alternatif ürünler kullanılmaya başlanmış ve agrega yerine kullanılan alternatif ürünlere fiber ilavesinin etkisi incelenmiştir. Yapılan çalışmaların en yaygınları kiriş numune üzerine yapılan eğilme dayanım testleridir. Bu çalışmada betonda kullanılan agrega yerine eşit hacimce madencilik işlemleri sonucu oluşan katı atıklar (bakır madencilik atığı, mermer atığı) ve uçucu kül kullanılmıştır. Bu katı atıkların kullanılması ile oluşturulan karışıma 4-6 kg/m3 polipropilen lif katılarak 40×40×160 mm boyutunda kiriş numuneleri dökülmüştür. Kiriş numuneler üzerinde; liflerin, ultrases geçiş hızı, eğilme ve basınç dayanımlarına etkisi incelenmiştir. Yapılan çalışmalar sonucunda liflerin basınç ve eğilme dayanımına olumlu etki yaparken, betonun su emme oranlarını ve yoğunluklarını etkilemediği belirlenmiştir. Son olarak ultrases geçiş hızının lif miktarı arttıkça azaldığı görülmüştür.

Anahtar Kelimeler: Eğilme dayanımı, maden atıkları, macun dolgu, sentetik lif, atiklar.

1. INTRODUCTION

The mixture that is created by mixing cement, water, and aggregate is called Composite. The use of different aggregate and the effect of fiber used in Composite have been investigated for many years. Using fibers is the most obvious method to eliminate cracks that are caused by the hydration of cemente. The disposal of micron-sized solid wastes, resulting from mining processes, is becoming more and more difficult. With developing mining methods, many mining enterprises across the world mostly prefer cement composite backfill (CPB) method in waste storage. CPB is a composite-filling mixture of mining operations created from waste with a certain proportion of binder and water (plantation, lake, or mains water). Moreover, marble enterprises' wastes of very fine powder and the fly ash generated by the factory chimneys have been becoming more and more difficult to store and dispose of.

Many fiber-like structures have been used to increase the resistance of the Composite against pressure and bending for a very long time. The efforts of the first people to strengthen bricks and mortar by using straws, goat hair, and human hair show that attempts to improve the nature of building materials go back to very old times. In fact,

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straw-reinforced bristle mortar (mud-brick), from which fiber-reinforced Composite was inspired, has been used as a building material for 4500 years. The use of building materials with the continuous reinforcing feature is as old as reinforced Composite [1,2]. We know the fact that during the construction of the Roman Colloquium, tail and mane hair of various animals were added to the clay mixtures, which can be named as the wet plaster. In Turkish Architecture, Horasan mortar used by Mimar Sinan in his works contained natural fibers such as straw [3-6].

The main reason for the use of fibers and similar structures in cement buildings is an attempt to remove the cracks formed in Composite. These cracks mean that the resistance to withstand the internal tension during the setting of Composite is inadequate. Composite, a mixture of simple cement, aggregate, and water has not changed until World War II. For a long period, cracks seen in Composite were overestimated considering that they were due to the nature of the product. [4,7,8].

In the early 1960s, the Union of American Armed Forces Engineers launched a research program on deflection and contraction cracks. The conventional methods used to reduce non-structural deflection and contraction cracks in Composite involve the coating of the surface using a liquid curing material or a covering; however, these measures induce the cracks to be capillary and did not prevent the expansion of cracks when the Composite is put under pressure [9,10]. At the end of the research program, it was concluded that "plastic contraction cracks were caused by dynamic internal tension that the Composite was exposed to until reaching the intended resistance value". It was also found that "fibers included in the Composite increased the ballistic resistance, energy damping, and impact resistance" [9,11,12].

According to the results of the studies, it was proven that the main role of fibers mixed in cement systems was to decrease the progress speed of cracks formed in the Composite in the matrix. Therefore, the maximum crack deformation of the material presents a significant increase when compared to any fiber-free composite. After reaching the maximum load, the rate of decrease speed as a result of increased deformation in fiber reinforced composite is much slower than normal composite. Thus, due to the separation and elongation of fibers from the matrix, the absorbed energy is rather high in fiber reinforced composite [13,14].

There is also a certain increase in the uniaxial compressive strength of composite with fiber addition. It is known that a significant increase in ductility and toughness is achieved in fiber-reinforced composite compared to fiber-free composite. In fiber-reinforced composite, among the parameters included in the composite compound, the factors that significantly affect the composite properties are the slenderness ratio and fiber amount [6,7,14].

In this study, the waste generated by the copper-zinc enrichment plant, the waste generated by marble cutting, and the fly ash were used as aggregate in the composite. With these wastes, 40×40×160 mm beam samples were poured. The effects of fibers on the mechanical properties of composite were investigated by adding different amounts of fibers to the poured beams. The usability of different mineral wastes in composite and their interaction with synthetic fibers were determined by conducting mechanical tests.

2. MATERIAL and METHOD

A. Material

In this study, copper mine tailings used in the production of marble waste, fly ash, fiber, cement, and putty fillers were used. The materials used in the study are given in Figure 1.

Figure 1. The materials used in the study

1. *Cement*: CEM I 42.5 R type cement was used in the composite produced. Cement is obtained from the Askale Cement Factory located in Gumushane. Table 1 shows the results of the chemical analysis of cement.

Table 1. Chemical, physical, and mechanical properties of cement

Chemical Properties (%)		Physical Properties	
SiO_2	18.59	Fineness modulus (retained on 45-µm sieve, %)	8.58
Al_2O_3	4.69	Specific gravity	3.08
Fe_2O_3	3.04	Specific surface area (cm^2/gr)	4145
CaO	60.34	Initial setting (hour-min.)	2h-33 min
MgO	1.92	Final set (hour-min)	3h-18 min
SO_3	2.89	Soundness (mm)	0.7
Loss of ignition	7.19	Water requirement %	29.9
Na_2O	0.11		
K_2O	0.64		
CI	0.0189	Mechanical properties (N/mm^2)	
		2.Day	23.9
		28.Day	51.1

2. *Fiber:* Polypropylene fiber (PP) was used in this study. Fiber properties are shown in Table 2. In this study, two ratios were determined as 4 and 6 kg/m^3. Although fiber volumes were kept the same in composite types, they differ in quantity due to their size, diameter, or thickness factors.

Table 2. *Fiber properties*

Fiber properties	**PP**
Fiber rate (kg/m^3)	4-6
Fiber length (mm)	50
Fiber width (mm)	0.5
Fiber thickness (mm)	0.25
Specific gravity (g/cm^3)	0.91
Tensile strength (MPa)	600-750
Elastic modulus (Mpa)	3800
Burning point (ºC)	537
Melting temperature (ºC)	180
Water absorption for ASTM D 570 (%)	0.01

3. *Copper Mine tailing:* Waste material was taken from the area within a distance of 75 m from the waste dump point of Gumustas mining area. In order to avoid oxidation by contacting air or contamination by any contaminant, the waste material was filled inside100 kg barrels and brought to the Composite Filling Laboratory (Figure 2).

4. *Marble Powder*: In this study; Marble powder generated by the blade of the marble saw was obtained from Gumushane. Chemical and physical analysis of marble powder is given in Table 3. The value of Fe_2O_3 content, which has a negative effect on cement hydration, is very low compared to the studies in the literature. Although it was very fine-grained, it did not show pozzolanic properties in pozzolanic activity experiments in terms of its physical properties (Table 3).

Figure 2. Taking the waste material used in the experiments from the waste dam and filling it into barrels

Table 3. Chemical and physical properties of marble powder

Chemical properties			Physical properties			
SiO_2+ Al_2O_3	Fe_2O_3+ MgO	CaO	Specific gravity	Specific surface area (cm^2/g)	Total organic carbon (%)	7-day pozzolanic activity (MPa)
1.69	0.31	55.12	2.72	3190	0.098	0

5. Fly Ash: Fly ash used in composite samples was obtained from Afsin Elbistan Thermal Power Plant. The chemical and physical properties of the supplied ash are shown in Table 4.

Table 4. Properties of fly ash

Chemical properties (%)		Physical properties	
Total SiO_2	23.08	Amount of material over 45 µ sieve (%)	4.0
Al_2O_3	6.25	Specific gravity	2.44
Fe_2O_3	2.58	Blaine (cm^2/g)	2496
CaO	47.03	Pozzolanic activity	15.8
MgO	1.60		
SO_3	14.61		
K_2O	0.47		
Na_2O	0.32		
Loss on Ignition	3.95		
Cl	0.0334		

B. Method

Beam samples with the dimensions of 4x4x16 cm were prepared to determine the tensile strength and toughness values. Samples remaining after the tensile strength test were cut into the parts with the dimensions of 4x4x8 cm and subjected to a compressive strength test.

1. Preparation of the composite mixture: Plant waste, mixture water, and binding materials used in this study were homogenized using a 20,8-liter capacity mixer (Univex SRMF20 Stand Model). The mixing process was carried out for 7 minutes at a speed of 105 rpm (Figure 3).

Figure 3. a) Preparation of the composite mixture, b) Materials used in the mixture

The mixing ratios and casting codes used in preparing the samples are given in Table 5.

Table 5. Mixture calculation for $1m^3$ fiber composite

Materials	Density (kg/m^3)	4LA Volume (m^3)	4LA Weight (kg)	4LM Volume (m^3)	4LM Weight (kg)	4LF Volume (m^3)	4LF Weight (kg)	6LA Volume (m^3)	6LA Weight (kg)	6LM Volume (m^3)	6LM Weight (kg)	6LF Volume (m^3)	6LF Weight (kg)
Fiber content	0.91	4.4	4	4.4	4	4.4	4	6.6	6	6.6	6	6.6	6
CMT*	3.66	748.2	2738	0	0	0	0	746.0	2730	0	0	0	0
Marble powder	2.72	0		748.2	2035		0	0		746.0	2029		0
Fly ash	2.44	0		0	0	748.2	1826	0		0	0	746.0	1820
Cement	3.08	97.4	300	97.4	300	97.4	300	97.4	300	97.4	300	97.4	300
Water	1	150	150	150	150	150	150	150	150	150	150	150	150
W/C		0.5		0.5		0.5		0.5		0.5		0.5	
Total		1000	3192	1000	2489	1000	2280	1000	3186	1000	2485	1000	2276

* Copper mine tailings

2. Preparation of sample molds and the indication of the slump: The prepared filling material has been poured into the sample molds with the dimensions of 4x4x16 cm in 3 levels to be applied to the clamping/placement process at each level. For each curing period, 4 samples were prepared for tensile strength and 8 samples for compression strength. In other words, experiments were carried out on a total of 18 samples for a group. Since there are 6 groups in total, the number of samples used in the study is 108.In addition to the water contained in the waste, mains water was used in the preparation of the waste samples. After the samples were prepared, they were kept at the drainage table for about 24 hours to allow better dehydration. At the end of this period, the samples were subjected to curing in the curing pool for 3, 7, and 28 days without allowing them to contact with air (Figure 4).

3. Determination of ultrasonic pulse velocity: The samples with the dimensions of 4x4x16 cm were tested in terms of ultrasonic pulse velocity (Figure 4). During the experiment, the transmission time was measured, and the length of the transmission path was divided by this value to calculate the ultrasonic pulse velocity.

Figure 4. UPV

4. Tensile strength: The tensile test was carried out on the 4x4x16 cm beam samples following the standard of TS-EN 12390-5 (Figure 5). Bending compressive strength tests were applied to 3, 7, and 28-day samples. Bending pressure is adjusted according to TS-314; and break loads and pressure tension (bending compressive strength) were determined.

Calculation of tensile strength:

$$f_{cf} = \frac{3 * F * l}{2 * d_1 * d_2^2}$$

f_{cf} = Tensile strength, MPa, (N/mm^2), F = Peak Load, (N), d_1, d_2 = Cross-sectional dimensions of the sample, (mm), l = Clearance between support rollers, (mm),

5. Compressive Strength: Compressive strength test was performed on composite samples according to TS EN 12390-3 standard. Compressive strength of the composite was calculated using the following equation:

$$f_c = \frac{F}{A_C}$$

f_c = Compressive strength, MPa (N/mm^2),

F= Maximum load at break (N),

A_c = Cross-sectional area of the sample where pressure is applied, (mm^2)

3. RESULTS AND DISCUSSION

A. Density and water absorption

As a result of the density analysis performed on the poured samples in accordance with the standards, copper mine tailings, which has heavy metal content, was found to have the highest density, and the composite with fly ash addition was found to have the lowest density (g/cm^3) (Figure 6). It has been found that the amount of fiber additive does not have much effect on the density, and generally, the density increases with the increase in the amount of fiber.

In the water absorption test performed in accordance with the standards, it was determined that the fiber addition affects water absorption. It was determined that beams prepared using 6 kg/m^3 fiber had a water absorption rate of 17%, while beams prepared using 4 kg/m^3 fiber had a water absorption rate of 14.90% (Figure 7).

B. Determination of ultrasonic pulse velocity

In the Ultrasonic Pulse Velocity Test performed on 4x4x16 cm beam samples, it was determined that the amount of fiber increases the void ratio (Figure 8). It was determined that polypropylene fibers affect sound transmission, and the speed of sound transmission decreases as the amount of fiber material increases.

Explanatory statistics on the ultrasonic pulse velocity of the samples are shown in Table 6.

The results of the experiments showed that the amount of fiber directly affects the ultrasonic pulse velocity (Figure 9).

As shown in Figure 10, in samples with copper mine tailings which are coded as 4LA, the UPV value of the 3-day sample is 2963 m/s, the UPV value of the 7-day sample is 3292.5 m/s, and the UPV value of the 28-day sample is 3365 m/s. The ultrasonic velocity was measured again after increasing the fiber content. The UPV value was found to be 2917.5 m/s at the 3-day sample, 3084 m/s at the 7-day sample, and 316.9 m/s at the 28-day sample (Figure 9).

In general, ultrasonic pulse velocity was observed to be higher in composite samples containing a higher content of marble and copper mine tailings. The main reason for this is that the fine grains interact more easily with the cement, thereby reducing the void ratio in the cement matrix.

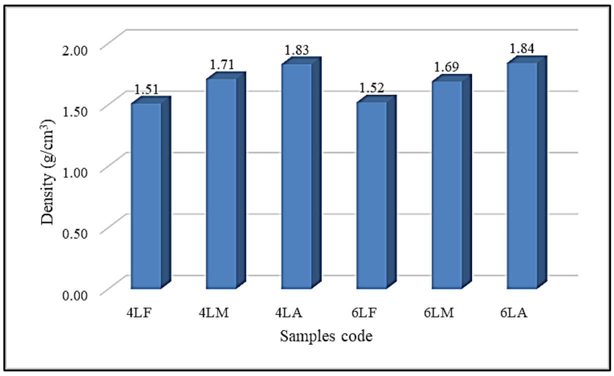


Figure 6. Density of beams

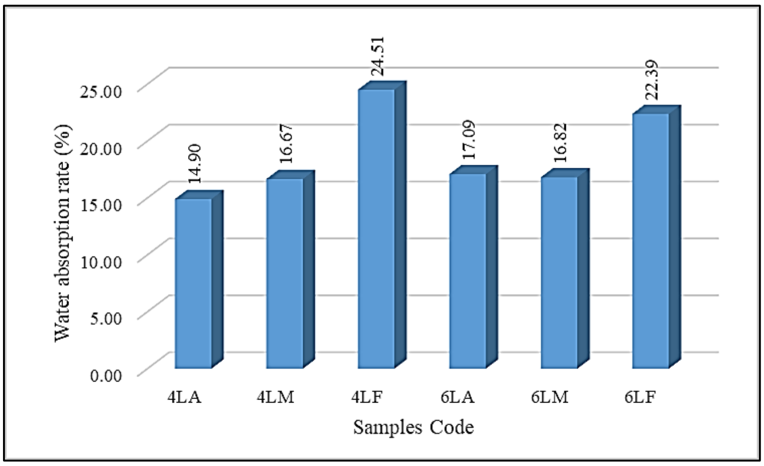


Figure 7. Water absorption rate of composite containing different amount of fiber

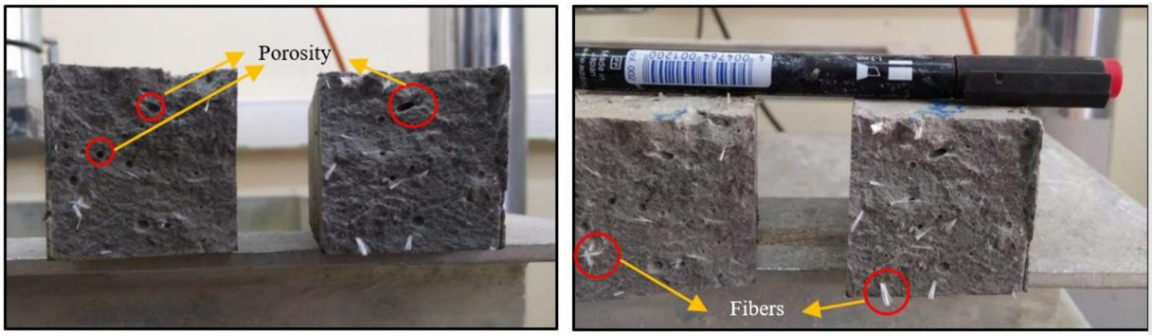
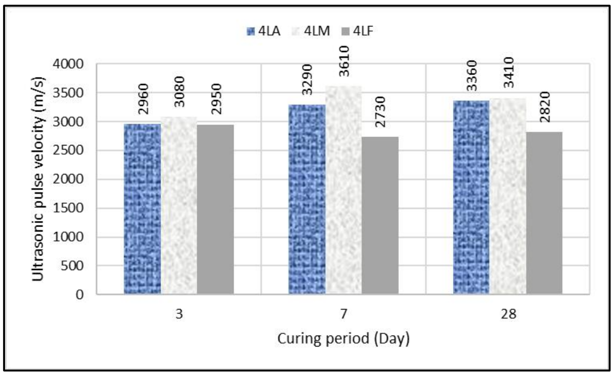


Figure 8. Fiber distribution and porosity structure in beam samples

Table 6. Explanatory statistics on experiment results.

Sample code	Number of samples	Arithmetic mean	Standard deviation	Min.	Max.
		3 Days			
4LA	4	2960.00	10.00	2955.00	2975.00
4LM	4	3080.00	18.71	3055.00	3100.00
4LF	4	2950.00	8.16	2940.00	2960.00
6LA	4	2920.00	11.55	2940.00	2960.00
6LM	4	3130.00	7.07	3120.00	3135.00
6LF	4	2720.00	9.13	2710.00	2730.00
		7 Days			
4LA	4	3290.00	8.16	3280.00	3300.00
4LM	4	3610.00	7.07	3600.00	3615.00
4LF	4	2730.00	9.13	2720.00	2740.00
6LA	4	3080.00	4.08	3075.00	3085.00
6LM	4	3310.00	4.08	3305.00	3315.00
6LF	4	2785.00	5.77	2780.00	2790.00
		28 Days			
4LA	4	3360.00	8.16	3350.00	3370.00
4LM	4	3410.00	4.08	3405.00	3415.00
4LF	4	2820.00	4.08	2815.00	2825.00
6LA	4	3170.00	5.77	3165.00	3175.00
6LM	4	3400.00	0.00	3400.00	3400.00
6LF	4	2950.00	4.08	2945.00	2955.00



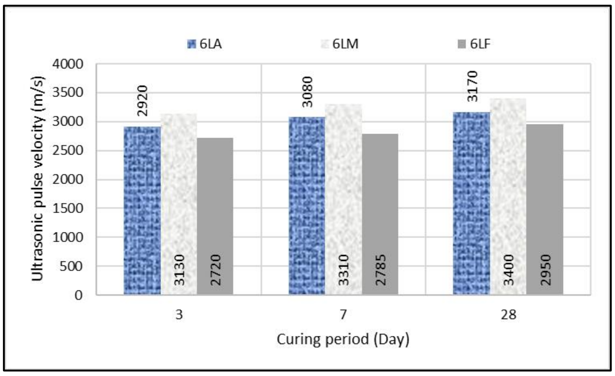


Figure 9. Ultrasonic pulse velocity

C. Tensile strength

The tensile test was carried out on 4x4x16 cm beam samples following TS-EN 12390-5 standard. Explanatory statistics on the tensile strength of the samples are shown in Table 7.

The results of the experiments showed that the amount of fiber directly affects the tensile strength, and the amount of fiber and the curing time was directly proportional to the tensile strength (Figure 10).

The beam samples with 4LA code, which were prepared with the addition of 4 kg fiber and copper mine tailings as aggregate in 1 m^3 composite, were observed to have a tensile strength of 7.24 MPa after 3 days, 7.30 MPa at the end of 7 days, 7.30 MPa at the end of 28 days. In addition, the beams poured using 6 kg of fiber in 1 m^3 composite have higher tensile strength compared to those of samples with 4 kg fiber addition for all curing periods. While it tended to decline by 1.8% at the end of 7 days, it increased to 4.7% at the end of 28 days

Table 7. Explanatory statistics on experiment results.

Sample code	Number of samples	Arithmetic mean	Standard deviation	Min.	Max.
		3 Days			
4LA	4	7.24	0.03	7.21	7.27
4LM	4	7.19	0.02	7.17	7.21
4LF	4	7.30	0.02	7.28	7.33
6LA	4	7.31	0.05	7.28	7.33
6LM	4	7.23	0.03	7.19	7.25
6LF	4	7.31	0.03	7.28	7.35
		7 Days			
4LA	4	7.30	0.02	7.28	7.32
4LM	4	7.20	0.03	7.15	7.23
4LF	4	7.31	0.04	7.25	7.35
6LA	4	7.43	0.08	7.30	7.48
6LM	4	7.30	0.05	7.23	7.35
6LF	4	7.40	0.05	7.35	7.45
		28 Days			
4LA	4	7.31	0.02	7.28	7.33
4LM	4	7.35	0.02	7.33	7.37
4LF	4	7.30	0.03	7.25	7.32
6LA	4	7.67	0.04	7.62	7.70
6LM	4	7.38	0.02	7.35	7.40
6LF	4	7.49	0.03	7.45	7.52

D. Compressive strength

Explanatory statistics on the compressive strength of the samples are shown in Table 8.

According to the results of the compressive strength test conducted in accordance with TS EN 12390-3 standards, the amount of fiber was found to have a negative effect on the compressive strength (Figure 11).

The beam samples coded as 4LA with 4 kg fiber and aggregate addition in 1 m^3 composite resulted in the compressive strength value of 12.22 MPa at the end of 3 days, 14.86 MPa at the end of 7 days, 7.30 MPa at the end of 28 days. It increased by 27.51% and resulted in compressive strength of 19 MPa.

The compressive strength test showed that the amount of fiber added into the mortar had little effect on the uniaxial compressive strength. It was observed that the strength decreased as the amount of fiber increased depending on the void ratio.

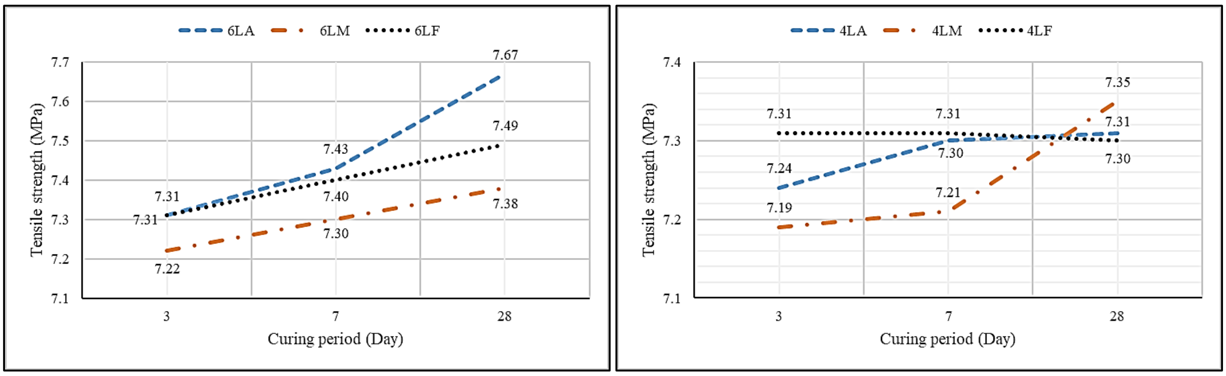


Figure 10. Tensile strength graph

Table 8. Explanatory statistics on experiment results.

Sample code	Number of samples	Arithmetic mean	Standard deviation	Min.	Max.
		3 Days			
4LA	8	12.21	0.17	12.00	12.40
4LM	8	15.19	0.13	15.00	15.30
4LF	8	7.16	0.12	7.00	7.25
6LA	8	9.53	0.06	7.15	7.25
6LM	8	12.62	0.05	12.55	12.68
6LF	8	7.38	0.08	7.28	7.46
		7 Days			
4LA	8	14.88	0.13	14.70	15.00
4LM	8	17.91	0.06	17.84	17.96
4LF	8	9.04	0.06	8.98	9.12
6LA	8	13.60	0.03	13.57	13.64
6LM	8	16.60	0.05	16.55	16.65
6LF	8	9.00	0.11	8.86	9.13
		28 Days			
4LA	8	19.00	0.29	18.70	19.30
4LM	8	22.89	0.11	22.75	23.00
4LF	8	13.13	0.20	12.94	13.33
6LA	8	18.44	0.09	18.35	18.57
6LM	8	20.64	0.10	20.50	20.70
6LF	8	14.10	0.21	13.80	14.26

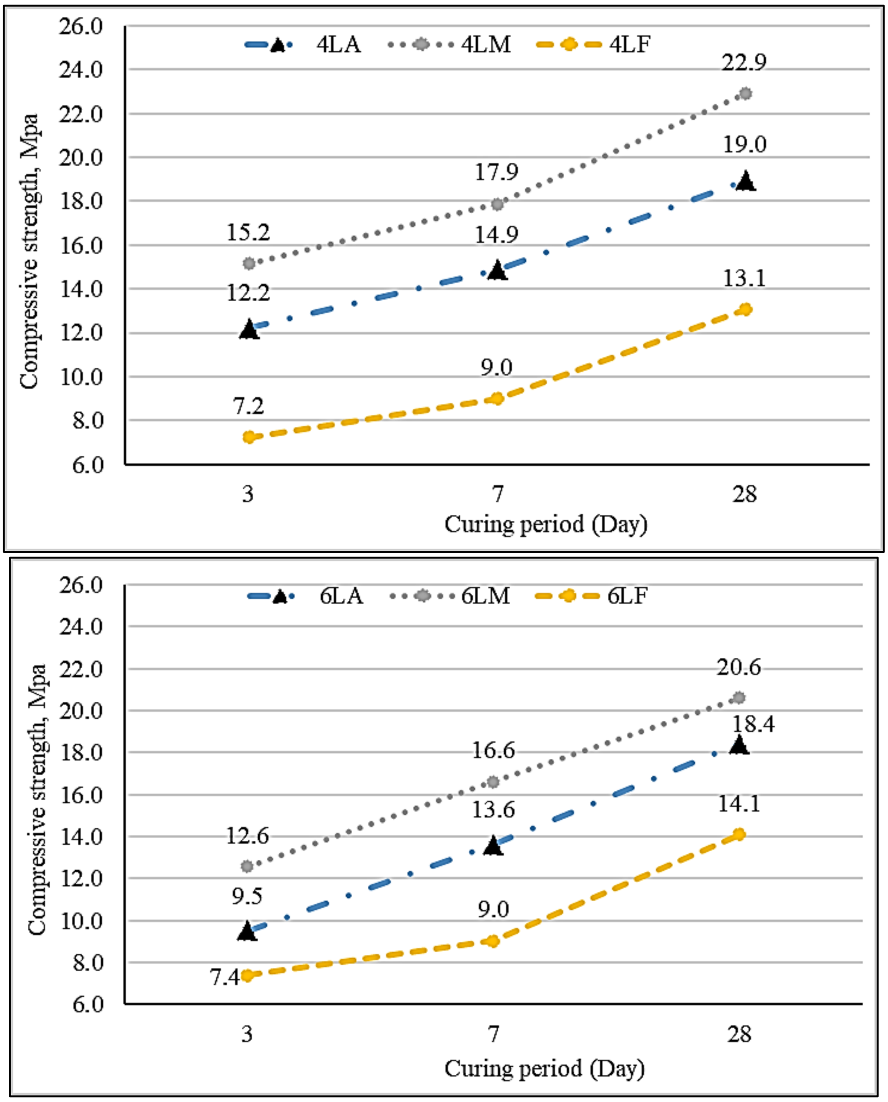


Figure 11. Compressive strength graph

4. CONCLUSIONS

The aim of this study is to increase crack control, ductility, tensile strength by using fiber in concrete. In addition, the use of solid waste material generated during production in mine sites is to determine an alternative use area. In this study, 40x40x160 mm beam samples were prepared using cement, water and mineral solid wastes instead of aggregate. Then, density, water absorption, tensile strength, and compressive strength tests were performed on samples. According to the results of the study:

It was determined that mineral waste, marble waste, and fly ash could be used in composite containing synthetic fiber. When the samples are evaluated in terms of density, the highest density is in 4 kg and 6 kg fiber added samples containing copper mine tailings and the density values are 1.83 kg/m^3 and 1.84 kg/m^3 respectively. The reason why the density of the samples produced with copper mine tailings is the highest is that the density of copper mine tailings is 3.66 g/cm^3. The density of copper mine tailings is higher than fly ash and marble waste.

In the evaluation of the 28-day compressive strength of the samples, it was determined that the samples prepared with marble waste and copper mine tailing were 11% and 3% less compressive strength, respectively, when using 6 kg of fiber additive and 4 kg of fiber additive. The decrease in the compressive strength with the increase of the fiber additive is due to the fact that there is clumping in the case of the increase in the fiber amount. In the use of fiber in concrete, there is a decrease in compressive strength with the increase in the fiber ratio (16, 17).

It has been determined that the compressive strength of composites prepared with marble powder, copper mine tailing and fly ash, regardless of the increase in fiber amount, has the greatest compressive strength in samples prepared with marble powder. The smallest compressive strength is in concretes using fly ash as aggregate.

Ultrasonic pulse velocity test of composite samples is similar to compressive strength values. Ultrasonic pulse velocity values of samples with high compressive strength were measured. The ultrasonic pulse velocity of composite samples with dense aggregate structure was faster (18).

It was determined that the amount of polypropylene fiber used increased the water absorption rate and the highest water absorption rate was found in composite samples prepared with 4% fiber and fly ash with 25.41%. The water absorption was determined as 22.39% in composite samples prepared with 6% fiber and fly ash.

Contrary to the decrease in compressive strength with the increase in the fiber amount, the bending strength increased with the increase in the fiber amount.

ACKNOWLEDGMENT

The authors would like to thank students of Gumushane University Faculty of Engineering and Natural Sciences, Department of Civil Engineering, Furkan UYGUR and Abdullah BAK for their support in laboratory studies.

DECLARATION OF ETHICAL STANDARDS

The author (s) of this article declare that the materials and methods they use in their studies do not require ethics committee permission and / or legal-specific permission.

AUTHORS' CONTRIBUTIONS

Gökhan KÜLEKÇİ: Performed the experiments and analyse the results.

Mustafa ÇULLU: Performed the experiments and analyse the results.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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