

AN EXPERIMENTAL COMPARISON OF THE MECHANICAL PROPERTIES OF CONCRETE USING WASTE SHEEP, GOAT WOOL, AND INDUSTRIAL FIBRES

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Abstract

Meanwhile, waste management and eco-friendly buildings are major concerns for the researcher. Utilizing garbage for developing concrete properties has become more and more important in recent years due to its low cost and ability to assess environmental maintenance. Industrial fibers like fiberglass and leftovers steel, as well as animal fibers like sheep and goat wool, have been added to concrete. As part of the investigation, 169 cubic samples of concrete and cylinders were examined in order to gain a thorough grasp of the mechanical properties of concrete. Four concrete mixtures with different fiber ratios (0–1.5%) of cement weight were investigated. The compressive and tensile strengths of concrete have been considerably enhanced by using one-year-old sheep wool fiber (SWF). The use of steel fiber enhances it as well. Additionally, the characteristics of the concrete were severely impacted by the goat wool fiber. Additionally, fiberglass has reduced the compressive strength by a specific percentage, just as SWF with eight-year-old sheep wool does. Focusing on the one-year-old SWF is a priority for the upcoming research.

Keywords:

Sheep Wool;
 Goat Wool;
 Fiberglass;
 Steel Fiber;
 Compressive Strength;
 Tensile Strength.

1 Introduction

Rapid urbanization is increasing global demand for cementitious materials in civil engineering, but conventional materials have energy, greenhouse gas, and environmental issues, necessitating research for environmentally friendly alternatives [1]. And since the construction sector accounts for 40% of CO₂ emissions, sustainable growth is necessary through the use of eco-friendly materials, CO₂ reductions, and the selection of recyclable, renewable, locally available, and environmentally acceptable raw materials [2]. Concrete, made from aggregates like sand, gravel, and crushed rock, is held together by a cement paste and water. Concrete has a very low tensile strength and a high compressive strength. Its properties are influenced by additives, such as steel rebars, fibers, and others that have utilized to improve the tensile strength [3-4]. Research on concrete performance advancements focuses on improving engineering qualities, adhering to environmental regulations, and improving tensile and flexural strengths, ductility, and durability in sustainable cementitious composites [5]. Although natural fibers have been utilized in building for thousands of years, in the twentieth century they were supplanted by industrialized materials such as concrete. However, environmental concerns in the building industry have brought natural fiber research back into the spotlight [6]. In parallel, researchers are looking into using wool in a variety of industries to remedy the environmental degradation caused by sheep and goat growing techniques in the region. Disposing of wool is either by that butchers dispose of sheepskin by scattering it around, or farmers spread the wool around the area following animal shearing, with little to no practical use. In order to improve the cement matrix and make it more ecologically friendly, scientists are investigating natural resources such as animal wool.

Sheep provide high-quality protein fiber called wool, which is used to make clothing and technological textiles [7]. Sheep and goat wool can be utilized as a fiber component to enhance concrete. Traditional reinforcing in concrete could be reduced or eliminated with fibers, but their high cost and lack of design rules discourage their use. Fibers preserve crack opening width and propagation while increasing capacity energy absorption and post-cracking tensile strength [8-9]. Fiber-reinforced

cementitious composite (FRCC) enhances concrete's mechanical response by enhancing strength and ductility, resulting in a deflection-hardening reaction in bending [10]. Fiber decreases steel congestion, limits crack width and spacing, eliminates brittle shear failure, and increases the shear strength of reinforced concrete beams (RCBs). Graded fiber reinforced concrete improves pre- and post-crack performance, increases ultimate strength, and inhibits the spread of cracks [11-12]. Fibers in concrete increase shear stiffness, ultimate bearing load, tensile strength, and deflection. They enhance ductility and resistance to primary tensile stresses. Fiber-reinforced concrete shows a slight increase in compressive strength. Furthermore, Splitting and bending tensile strength increases [11, 13-14]. Concrete with micro or short, randomly distributed fibers enhances pre-crack strength and prevents micro cracks from forming [15]. Fiber length and volume have a major impact on strain hardening, and the right ratio of fibers can increase deformation and strength, which will improve performance overall [12]. In civil engineering, sheep wool is a natural fabric that is used to reinforce composites and offer acoustic and thermal insulation. Compared to cotton and rayon, it is more resistant to tension due to its mechanical and chemical characteristics. Within a 25% to 30% range, wool fibers can retain their form without losing length. To put it simple, as a fiber effect, utilizing steel fibers results in an increase in shear stiffness. Using steel fibers can significantly increase ductility. Once the cracks appear, the fibers begin to work, causing the stress to be distributed more evenly throughout the fracture area. Furthermore, until the fibers break, they remain resistant to the main tensile stresses. Compared to normal concrete, specimens made of fiberglass have a higher tensile strength and a greater capacity for deformation. Finally, A high SWF percentage can improve ductility, decrease waste, and raise the bending strength of mortar [7, 11, 13, 16-20].

Eco-design, a concept focusing on sustainable construction, considers soil quality, air and water quality, and human health. It involves reduced energy usage and intelligent design, challenging common misconceptions about eco-design. Because of their growing demand and profitability, natural fibers are finding themselves employed more and more in composite reinforcement in industries including structural engineering, automotive, and packaging [17]. This research explores the use of raw wool in the construction sector as a concrete composite, potentially encouraging the government to introduce environmental legislation, as it could improve the livestock industry and revive the industrial sector. The goal of this project is to promote sustainable solutions for local and global use by expanding the use of animal wool as a concrete matrix. By analyzing the impacts of fibers on concrete, the study seeks to improve the poor tensile strength and compressive strength of concrete and maybe enhance the livestock sector. The purpose of the paper is to investigate how various fibers, including fiberglass, recycled steel fiber, and goat and sheep wool, affect the compressive and tensile strength of concrete. One of the requirements is to sort the sheep's wool by age and determine whether there are any variations. Additionally, a comparison between all of these fibers and plain concrete will be examined.

2 Experimental Works

2.1 Materials

A number of tests were conducted on all of the materials utilized in the study in the civil engineering lab at the University of Mosul. First, the cement was subjected to chemical and physical testing. The following table displays the findings. All of the tests were confirmed to meet Iraqi standards [21]. It is important to note that the cement, which comes from a locally produced source (Tasluja), complies with Iraqi standards (IQS, No. 5, 1984), second revision, 2010. The details are reflected in Table (1) and Table (2).

Table 1: Physical Properties for Cement.

Properties	Results	Limits of Iraqi Specification No.5
Standard ductility	0.28	--
Initial Setting Time [minutes]	120	≥ 45
Final Setting Time [hrs.]	4:15	≤10
3 days Compressive Strength [MPa]	22.8	≥16
7 days Compressive Strength [MPa]	43	≥24
Fineness Sieve NO. 170 [%]	2.5	≤10

Table 2: Chemical Properties for Cement.

Chemical Compounds	[%] by weight	Limits of Iraqi Specification No.5
C ₂ S	34.2	28.61-37.9
C ₃ S	36.44	31.3-41.05
C ₃ A	12.07	11.96-12.3
C ₄ AF	7.98	7.72-8.02
SiO ₂	20.59	17-25
Al ₂ O ₃	5.92	3-8
Fe ₂ O ₃	3.29	0.5-6
CaO	64.16	60-67
MgO	2.2	≤ 5%
SO ₃	2.21	≤ 2.8
Free lime	0.76	0.66-1.02
Loss on ignition	0.8	≤ 4%
Insoluble residue	1.75	≤ 1.5
Solid solution	18.53	-

Regarding aggregate, the materials were sourced from the Tigris River. A group of the tests were performed on the sand and the gravel in line with [22-27]. According to the sieves highlighted in Iraqi standards No. 45/1984 (5-20) mm and No. (IQS, No. 45, 1984), second revision, 2010, the aggregate was sieved and tested with highlighted ASTM (D75, C702, C128, C127, C136, C29) tests; the aggregate was tested, and the mechanical properties are listed in Table 3. All of these tests helped in designing the concrete mix design.

Table 3: Mechanical Properties for Sand and Gravel.

Materials	Relative density (specific gravity) [OD]	Relative density (specific gravity) [SSD]	Density (OD) [Kg/m ³]	Density (SSD) [Kg/m ³]	Bulk Density [Kg/m ³]	Fines Modulus	[%] Absorption
Coarse Aggregate	2.65	2.69	2650	2685	1712.7	2.17	1.3
Fine Aggregate	2.58	2.69	2574	2681	1586.7	2.81	4.16

2.1.1 Fibers Preparation

The samples of wool were collected from a farm with in excess of 200 sheep and goats in the Barzeria plateau in Iraq, north of Zakho. The sheep were Kurdish, aged one, two, and eight years, with an average weight of 30-50 kg. While goats were six and seven years old. Shearing is one of the three primary methods used in the study to prepare wool for sheep and goats, as it guarantees high-quality wool free of drying or debris. As reflected in Figure (1), the wool was washed by hand, dirt was removed, and it was soaked in water for 10 minutes. The dirt was then removed, and the wool was then soaked in water for 5-6 hours to remove soil, straw, and animal excrement. The water was then discharged. Wool was washed twice with Fairy soap, using surfactant to break down oil. The soap was applied to the wool, then trampled underfoot for five minutes. After filling the bucket with water, the wool was trampled for ten to fifteen minutes. The soap was then lathered with clean water, ensuring complete removal. This process was applied to all wool. Finally, the wool was soaked in salt water for 48 hours, promoting surface stiffness and easier concrete bonding. The water was then disposed of and exposed to sunlight for two days [28].

Wool was transported to Al Qayyarah for carding, ensuring smooth spinning. Each batch was passed twice and then through the spinning process. Fiber was pulled and stretched before drafting, and a hand spindle was used. The spooling was double-lined. After receiving yarn, fiber strands were cut into 20-30 mm pieces depicted in Figure (2). Since fiberglass is a predetermined length, the lengths of the SWF, GWF, and StF are prepared to be nearly that in order to have a similar length among all the fibers. Moreover, fiber lengths of 20–30 mm offer higher shear stiffness, larger deformation capacity, and better post-cracking control [12-13].

Type E glass monofilament, which had been cut, was used as the fiber. The fibers underwent silane-based sizing to improve their initial binding and dissociation. Extremely fine, single filament fibers with a diameter of 13 microns, the fibers were cut to lengths of 18 mm in accordance with the

requirements for surface appearance and maximum aggregate size. 0.6 kg biodegradable paper bags were used to wrap the fibers [29].

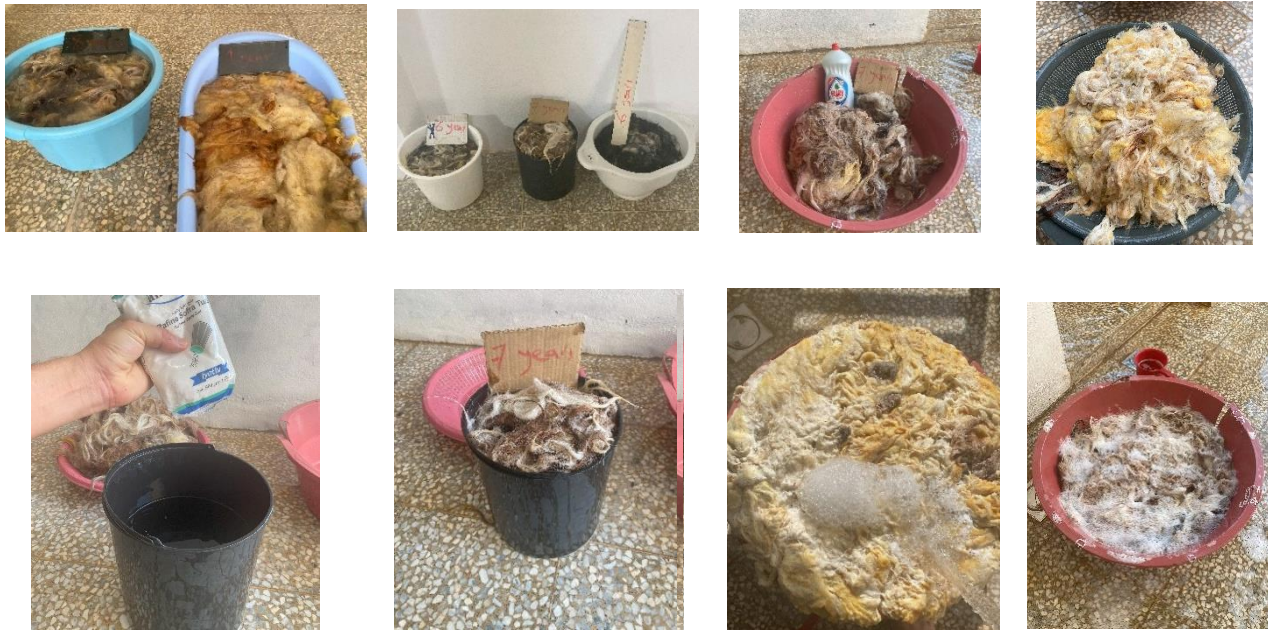


Fig. 1: Wool Washing Procedure.



Fig. 2: Carding and Spinning Wool.

As shown in Figure 3, steel wire is used to tie steel reinforcement, but lost ends were finally cut. The cut-off ends of steel bars were used to create steel fiber, which was then added to concrete, reducing environmental impact by disposing of loose wire.



Fig. 3: Fiberglass and Steel Fiber.

2.1.2 Desing of Concrete Mix

A significant detail to note is that the design is based on (ACI 211.1-91). The planned compressive strength of concrete is 25 MPa. The composition's main components were fiber, sand, aggregate, and Portland cement. A variety of factors were considered. One of the expected challenges in the blend was workability. The sources under review indicate that wool absorbs between 30 and 40 percent of its weight in water [30]. It was therefore expected that the mixture would have hard concrete or be less workable. The slump was selected based on the highest amount allowed in our case because it enhances performance, which is an important task. The design required a maximum size for coarse aggregate, which was determined to be 20 mm. The materials were provided to the site, and then it proceeded with the sieve analysis tests; it has figured out that the maximum aggregate size was 20 mm. The amount of mixing water and air entrapped was determined using slump amount and aggregate size. The water-to-cement ratio was determined using non-air-entrained data and compressive strength. The volume of coarse aggregate was calculated using fine modulus and maximum aggregate size. The quantity of fine aggregate was easily determined by converting the provided information to volumetric, with Table 4 listing the quantity of ingredients. Regarding the fiber addition, it is based on the weight of the cement. The planned percentages of fibers are 0.5%, 1%, and 1.5% of the weight of cement. Any amount over 1-1.5% has a significant chance of weakening the concrete's strength and reduce workability [28,31-32]. As part of the research is understanding the age factor of animals on the properties of wool, it is better to keep the fiber percentages within the ideal percent. Concrete mixing followed the coming procedure. Prior to mixing the fiber, the fine aggregate had been blended with the coarse aggregate. Seeking to achieve consistency, all of these ingredients were mixed for three to five minutes. Cement was then added, and after the ingredients were combined for over three minutes, water was added, and the mixture was well mixed to make the mixture as uniform as feasible.

Table 4: Concrete Mix-Design for (1.0 m³) of Concrete.

Percentage of Fibers	Cement [Kg]	Water [Kg]	Coarse aggregate [Kg]	Fine aggregate [Kg]	Fiber Percent of cement [Kg]
0.5 %	336	163	1076	722	1.68
1.0 %					3.36
1.50 %					5.04

2.1.3 Experimental Tests

2.1.3.1 Compressive strength

A key mechanical property of structural concrete is its compressive strength, which is the maximum stress a material or structural element can bear before collapsing. To investigate the behavior of various concrete forms with fiber addition under a compression mechanism, 114 cube molds of 150 x 150 x 150 mm concrete were made. In accordance with British standard EN 12390-4, specimens were loaded. As soon as the specimens were taken out of the curing process, but no later than ten hours, their strength was assessed. Before the test, all bearing surfaces on the testing equipment were cleaned of any loose grit or extraneous debris [33]. The specimens were tested at two different ages: seven and twenty-eight days. Figure (4) depicts the equipment used to measure compressive strength.

2.1.3.2 Split Tensile Test

With 55 samples cast to replicate the sample mixture, the split tensile test evaluates the tensile strength of concrete across all fiber-added concrete groups. A standard test cylinder for concrete specimens, 300 mm by 150 mm in diameter, was placed horizontally between the loading surfaces of the compression testing apparatus. The compression force was applied uniformly and diametrically along the cylinder's length until the cylinder failed at the vertical diameter, Figure (5). To ensure even load distribution and lower compressive stresses, steel plate strips were positioned in between the specimens and loading platens. The samples were examined at 28 days of age in compliance with ASTM C496/C496M [34].



Fig. 4: Compressive Strength Test.



Fig. 5: Split Tensile Test.

3 Results and Discussion

3.1 Compressive Strength Test

3.1.1 Fiberglass

Compressive strength tests were performed on samples at ages of 7 and 28. Tables and bar charts are used to display the results. Regarding the fiberglass. Table 5 shows the average compressive strength values of concrete cubes, and Figure 6 portrays the compressive strength of 7 and 28 days; the fiberglass negatively impacts one of the concrete's properties with percentages of 0.5 and 1, respectively. The fiber's quality, kinds, and aspect ratio (length-to-diameter ratio) could all be the reasons behind this drop in the strength. Concrete's compressive strength marginally improves with a percentage of 1.5. Another issue at the same percentage was the workability of the concrete. The concrete was firm. If the percentage is raised beyond 1.5, the compressive strength can increase. On the other hand, another problem with workability is almost certain to arise. It was firm concrete. One of the issues noticed during the material mixing process was the fiber collapsing under the pressure of other components.

Table 5: Average Compressive Strength of Concrete with Fiberglass Cubes.

Name	Fiber [%]	Average compressive strength [MPa]	Increased percentage or decrease percentage
7 days compressive strength			
Controller	0	25.64	
Fiberglass	0.5	23.99	-6.435
	1	23.12	-9.828
	1.5	25.7	0.234
28 days compressive strength			
Controller	0	33.01	
Fiberglass	0.5	29.93	-9.331
	1	31.11	-5.756
	1.5	33.17	0.485

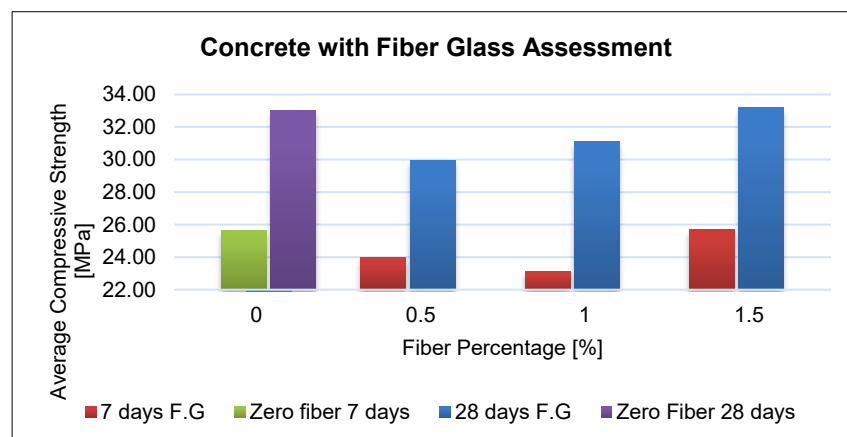


Fig. 6: Concrete's Compressive Strength with Fiberglass after Seven and Twenty-eight Days.

3.1.2 Sheep Wool Fiber

In contrast to regular concrete, the compressive strength of the wool fiber from one-year-old sheep has increased. At dosages of 5.04 kg/m³ at 28 days and 1.68 kg/m³ at 7 days, the fiber-reinforced concrete containing sheep wool fiber (SWF) increased in compressive strength by 20.87% and 24.1%, respectively. At both ages, it is clear that the other percentages have climbed. Furthermore, the most important factor is that, on average, the concrete's compressive strength is 20% higher than zero-fiber concrete after seven days of age. Figure (7) shows the compressive strength after 7 and 28 days, and Table 6 shows the average compressive strength of concrete cubes. This is a very crucial signal that might be used instead of the additive that is used as an accelerator to speed up the hardening process. Faster formwork turnaround, quicker construction, and early load-bearing capacity could all result from it. The question of why the increase is not gradual may be one that is brought up. The distribution of the fiber in the mixture is not uniform, which is most likely the cause. Comparing sheep wool fiber (SWF), one-year-old sheep, and fiberglass fiber (FG) in a brief manner. There is a clear distinction between the two. The percentages for the seven days are 0.5, 1, and 1.5; the sheep's compressive strength increases to 24.6%, 20.9%, and 15.8%, respectively. The rise percentages of the SWF over the 28-day period are 17.8%, 13.4%, and 16.8% for the fiber percentages that are underlined. In short, SWF improves the compressive strength of concrete far more than FG does for concrete. This concept is also supported by [35].

Table 6: Average Compressive Strength of Concrete with Sheep Wool Fiber Cubes (One Year Age).

Name	Fiber [%]	Average compressive strength [MPa]	Increased percentage or decrease percentage
One Year Sheep Aged			
7 days compressive strength			
Controller	0	25.64	
Sheep Wool Fiber (SWF)	0.5	31.82	24.103
	1	29.23	14.002
	1.5	30.53	19.072
28 days compressive strength			
Controller	0	33.01	
Sheep Wool Fiber (SWF)	0.5	36.43	10.360
	1	35.91	8.785
	1.5	39.9	20.872

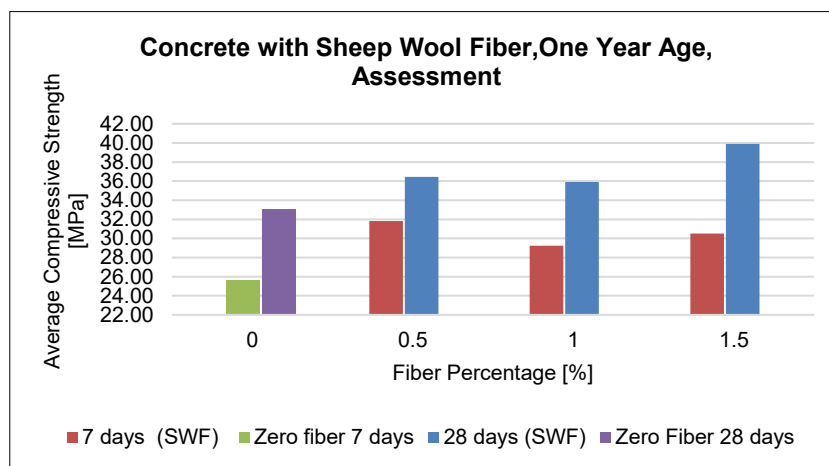


Fig. 7: Concrete's Compressive Strength with Sheep Wool Fiber (One Year Age) after 7 and 28 Days.

Two-year-old sheep wool fiber concrete has a slightly higher compressive strength than ordinary concrete (see Table 7 and Figure 8). With a percentage of 0.5, concrete aged for seven or twenty-eight days produces the most efficient contribution. Nevertheless, SWF's influence decreases with increasing proportion; it is essentially insignificant. It is noticeable that the fiber of sheep that are one year old is substantially better than that of sheep who are two years old. In short, the quality of the fiber is influenced by the animal's age. A one-year-old's wool is stiffer and better to address as a fiber than that of an older

animal. At seven days of age, the compressive strength of SWF concrete is, on average, 10.9% higher than that of regular concrete. This is another crucial element that can be used to quickly harden concrete. Sheep wool fiber (SWF), two years old, and fiberglass fiber (FG) are evaluated. There is a difference between the two. Following a seven-day period, the sheep's compressive strength increases to 19.5%, 16.5%, and 7.5%, respectively, with percentages of 0.5, 1, and 1.5. In terms of the fiber percentages that are emphasized, the SWF increased by 14.7%, 7%, and 3.9% over the course of the 28-day period. In short, for concrete of both ages, SWF yields a greater improvement in compressive strength than FG. Additionally, the sheep wool fiber from the one-year-old is more prolific than this one when compared to the SWF from the first two ages.

Table 7: Average Compressive Strength of Concrete with Sheep Wool Fiber Cubes (Two Years Age)

Name	Fiber [%]	Average compressive strength [MPa]	Increased percentage or decrease percentage
Two Years Sheep Aged			
7 days compressive strength			
Controller	0	25.64	
Sheep Wool Fiber (SWF)	0.5	29.8	16.225
	1	27.71	8.073
	1.5	27.8	8.424
28 days compressive strength			
Controller	0	33.01	
Sheep Wool Fiber (SWF)	0.5	35.08	6.271
	1	33.48	1.424
	1.5	34.52	4.574

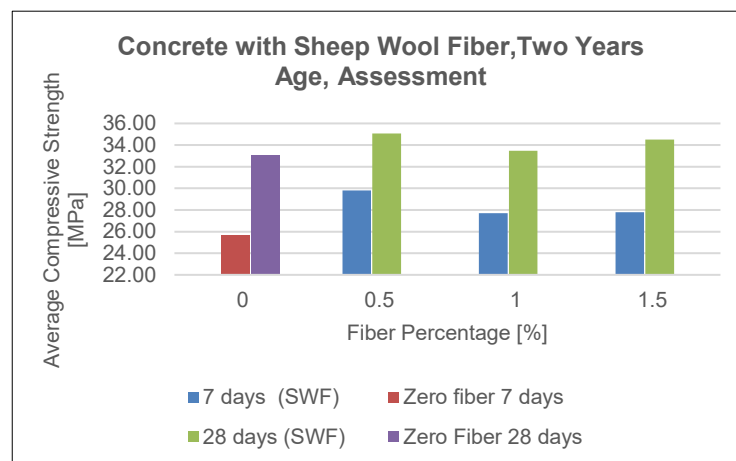


Fig. 8: Concrete's Compressive Strength with Sheep Wool Fiber (Two Years Age) after 7 and 28 Days.

Concrete aged 7 and 28 days, concrete with SWF aged eight years, is compared to plain concrete. The strength is significantly increased at a percentage of 0.5. The enhancement percentages are 24.4 and 15, respectively; however, the concrete that is 28 days old and contains 1% SWF has a decrease in compressive strength; the other significant finding is that the 1.5% fiber gain was essentially unchanged over the seven- and twenty-eight-day periods; and finally, the defect grows with the percentage of fiber additive. Wool fiber for sheep aged eight years compared to plain concrete contributes positively to the compressive strength, but the increase is not very noticeable, especially when looking at the proportion of fiber with 1 and 1.5. All are shown in Figure (9) and Table 8. It makes clear that sheep wool fiber is more valuable than fiberglass when comparing the SWF and FG at 7 and 28 days. To identify the best form of SWF that more effectively increases compressive strength, as shown in Figure (10). The concrete's 28-day compressive strength was more significantly influenced by the fiber from one-year-old sheep's wool.

Table 8: Average Compressive Strength of Concrete with Sheep Wool Fiber Cubes (Eight Years Age).

Name	Fiber [%]	Average compressive strength [MPa]	Increased percentage or decrease percentage
Eight Years Sheep Aged			
7 days compressive strength			
Controller	0	25.64	
Sheep Wool Fiber (SWF)	0.5	31.89	24.376
	1	30.09	17.356
	1.5	27.27	6.357
28 days compressive strength			
Controller	0	33.01	
Sheep Wool Fiber (SWF)	0.5	37.95	14.965
	1	31.06	-5.907
	1.5	34.88	5.665

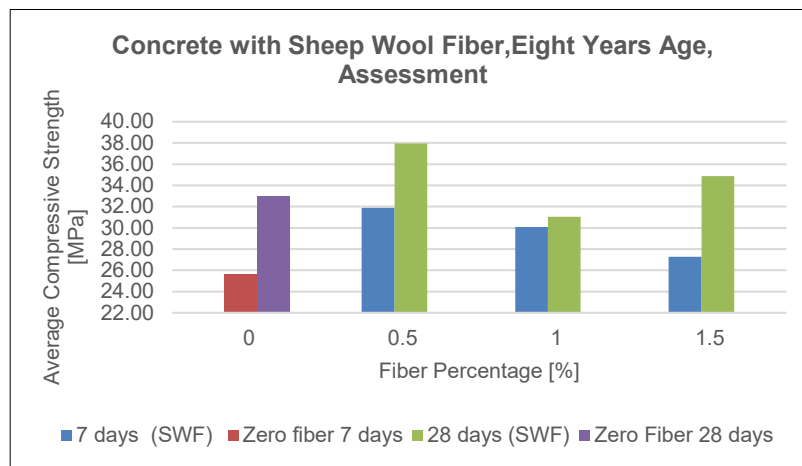


Fig. 9: Concrete's Compressive Strength with Sheep Wool Fiber (Eight Years Age) after 7 and 28 Days.

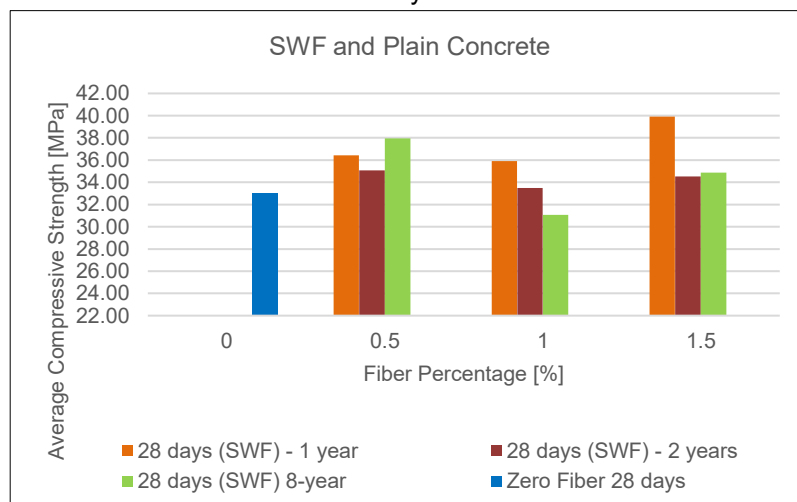


Fig. 10: Concrete's Compressive Strength with SWF at Different Ages.

3.1.3 Goat Wool Fiber

Investigating how compressive strength is impacted by goat wool fiber (GWF). There is virtually little contribution from this type of fiber. There is also a noteworthy 1.5% at 28 days of concrete age; the influence was negative. There could be several explanations, such as the goat's age, which caused the wool to absorb more water than the others since it was weak and excessively dry, or the carding of the goat fiber that was collapsing during mixing. Figure (11) and Table 9 illustrate all of this. It begs the question of why SWF works better. The collapse of the carding of the goat fiber during mixing is one of the reasons. Regarding recycled steel fiber.

Table 9: Average Compressive Strength of Concrete with Goat Wool Fiber (GWF) Cubes.

Name	Fiber [%]	Average compressive strength [MPa]	Increased percentage or decrease percentage
7 days compressive strength			
Controller	0	25.64	
Goat Wool Fiber (GWF)	0.5	26.14	1.950
	1	28.45	10.959
	1.5	26.33	2.691
28 days compressive strength			
Controller	0	33.01	
Goat Wool Fiber (GWF)	0.5	34.39	4.181
	1	35.23	6.725
	1.5	31.56	-4.393

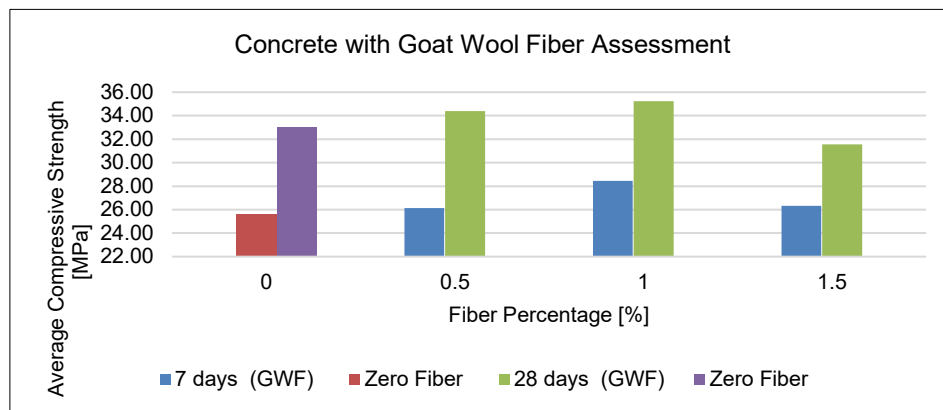


Fig. 11: Concrete's Compressive Strength with Goat Wool Fiber after 7 and 28 Days.

3.1.4 Recycled Steel Fiber

Steel fiber dramatically improves compressive strength at different fiber addition percentages, as seen in Figure (12) and Table 10. Comparing SWF (one-year-old) with the recycled steel fiber, at 0.5% and 1% of fiber addition, when the age of concrete is 7 days, the compressive strength of concrete with SWF is higher than concrete with recycled steel fiber. In contrast, it is the opposite when the concrete age is 28 days.

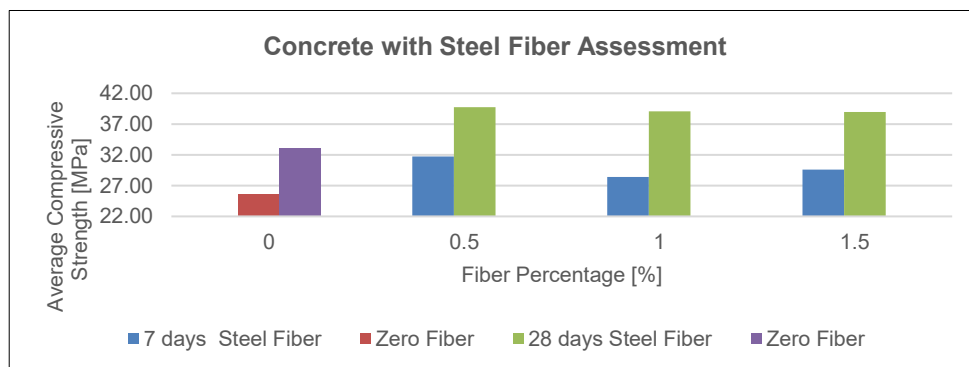


Fig. 12: Concrete's Compressive Strength with Steel Fiber after 7 and 28 Days.

Table 10: Average Compressive Strength of Concrete with Steel Fiber Cubes

Name	Fiber [%]	Average compressive strength [MPa]	Increased percentage or decrease percentage
7 days compressive strength			
Controller	0	25.64	
Steel Fiber	0.5	31.74	23.791
	1	28.43	10.881
	1.5	29.59	15.406
28 days compressive strength			
Controller	0	33.01	
Steel Fiber	0.5	39.72	20.327
	1	39.08	18.388
	1.5	38.98	18.085

3.2 Split-Cylinder Test

The ideal 1% fiberglass content serves to improve the tensile strength of concrete up to 28 days of age. Compared to regular concrete, the strength of the concrete simply drops after that percentage, even though the gain is quite good. Table 11 and Figure (13) provide other details. After the cylinders failed, it was evident that the fibers were holding the pieces together tightly. A fault in the concrete resulted from the fibers balling up during mixing, creating air spaces. examining the effects of the sheep wool fiber (SWF) on the tensile strength characteristics of the concrete. Table 12 and Figure (14). The percentage of concrete's tensile strength increases most when wool with 0.5 of one-year-old sheep fiber is used, followed by 0.5 of two-year-old sheep fiber. Then, adding wool that has one percent one-year-old sheep fiber also increases the concrete's tensile strength. Nonetheless, it is clear that concrete is negatively impacted by eight-year-old sheep wool fiber. Sheep wool fiber that is one year old has the highest positive impact of all the fibers. At a dosage of 0.5%, SWF and FG are almost exact equivalents. Still, at the higher percentage, 1%, FG is noticeably better than SWF. In summary, of all the fiber kinds, at 0.5 percent, SWF that is one year old is superior. At 1.5 percent, FG is at the top, followed by a year-old SWF. Last but not least, one-year-old SWF is requested after steel fiber for 1.5%.

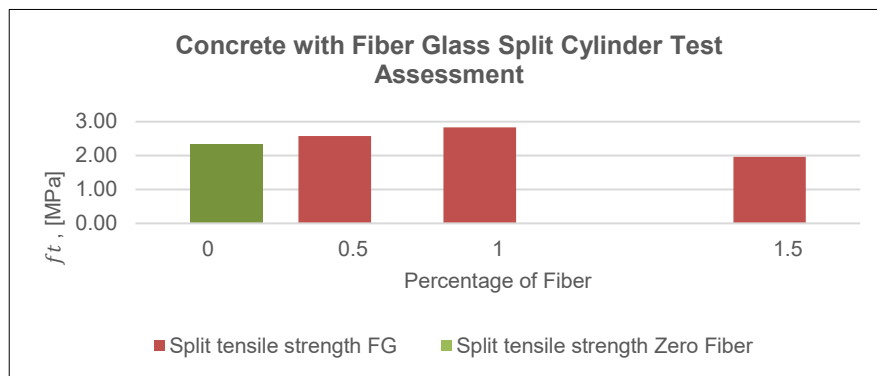


Fig. 13: Concrete's Split Tensile Strength with Fiberglass (28 Days).

Table 11: Average Split Tensile Strength of Concrete with Fiberglass.

Name	Fiber [%]	Splitting Tensile Strength [MPa] [ft]	Increased percentage or decrease percentage
Fiberglass (FG)			
28 days concrete age			
Controller	0	2.34	
Fiberglass	0.5	2.58	10.256
	1	2.83	20.940
	1.5	1.96	-16.239

Table 12: Average Split Tensile Strength of Concrete with Sheep Wool Fiber.

Name	Fiber [%]	Splitting Tensile Strength [MPa] [ft]	Increased percentage or decrease percentage
28 days concrete age			
One Year Aged			
Controller	0	2.34	
Sheep Wool Fiber (SWF)	0.5	2.61	11.538
	1	2.44	4.274
	1.5	2.34	0.000
Two Years Aged			
Controller	0	2.34	
Sheep Wool Fiber (SWF)	0.5	2.47	5.556
	1	2.41	2.991
	1.5	2.44	4.274
Eight Years Aged			
Controller	0	2.34	
Sheep Wool Fiber (SWF)	0.5	2.07	-11.538
	1	1.99	-14.957
	1.5	1.94	-17.094

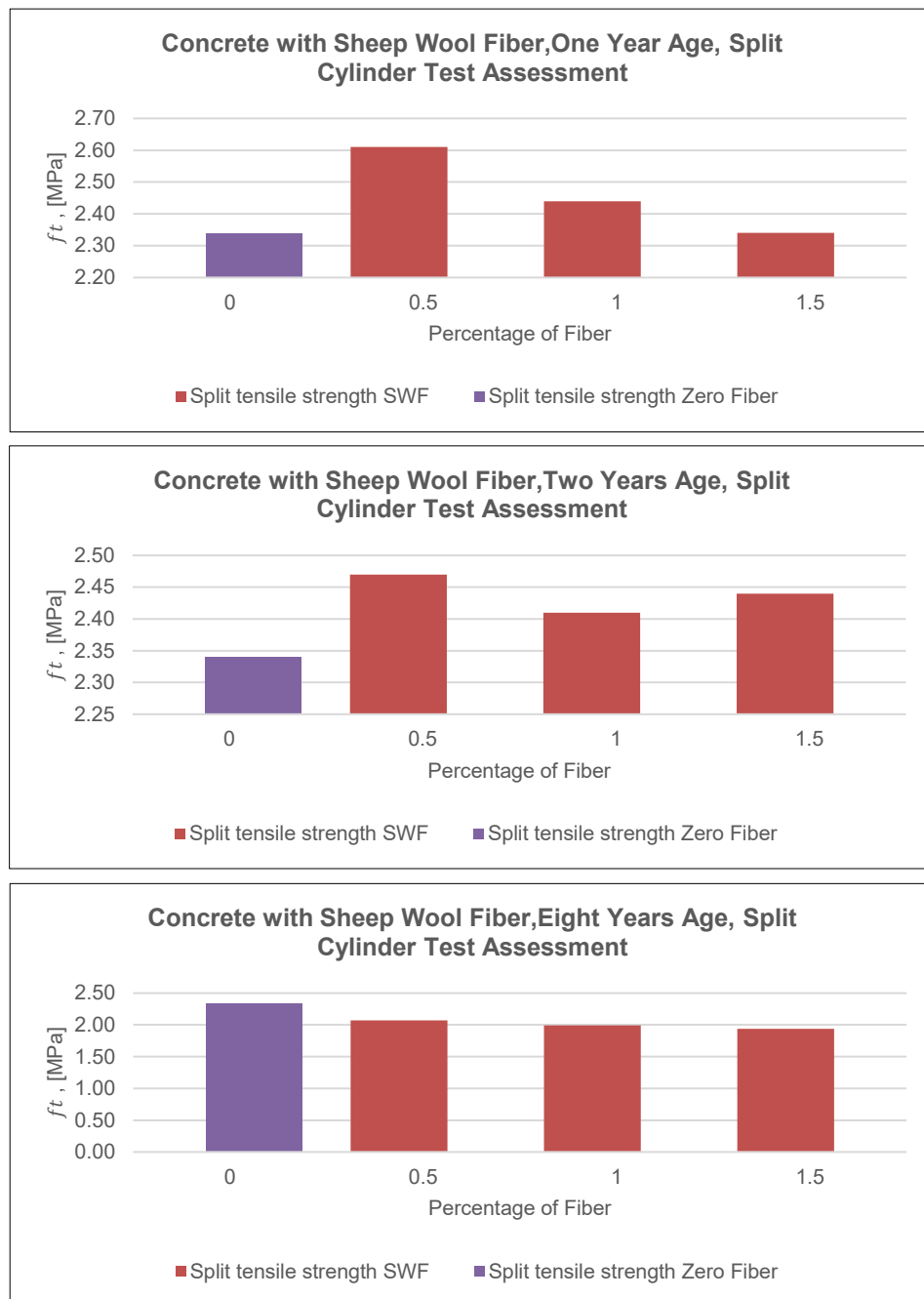


Fig. 14: Concrete's Split Tensile Strength with Sheep Wool Fiber (Different Years Ages).

The effects of goat fiber on the properties of the concrete are illustrated in Figure (15) and Table 13. Concrete is clearly negatively impacted by GWF. Age does have an effect, and previous data suggests that the animal's age may be one of the explanations. The goats used in the experiment were six and seven years old. This could be one of the reasons.

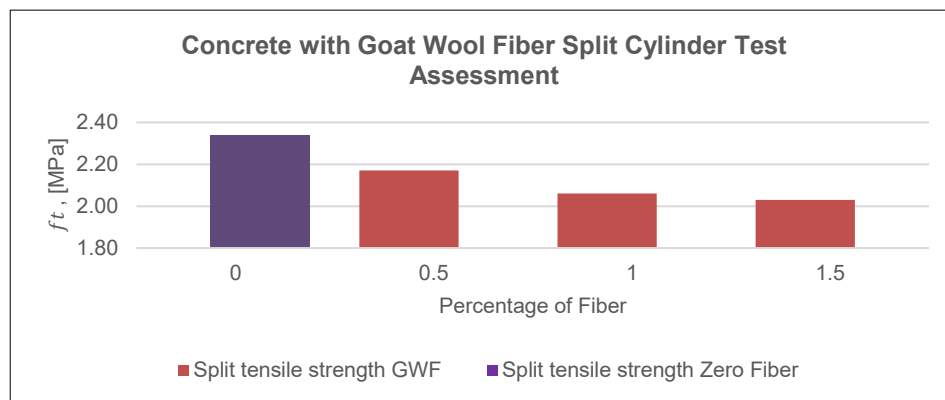


Fig. 15: Concrete's Split Tensile Strength with Goat Wool Fiber (28 Days).

Table 13: Average Split Tensile Strength of Concrete with Goat Wool Fiber.

Name	Fiber [%]	splitting tensile strength [MPa] [ft]	Increased percentage or decrease percentage
28 days concrete age			
Controller	0	2.34	
Goat Wool Fiber (GWF)	0.5	2.17	-7.265
	1	2.06	-11.966
	1.5	2.03	-13.248

Steel fiber has a major effect on concrete's tensile strength, particularly when the proportion is 1.5. It has greatly improved the strength of the concrete. Furthermore, 0.5% contributes favorably to the strength as well. The sample may have errors pertaining to the negative component. Therefore, it is recommended that more research be done in that particular area. Details are reflected in Figure 16 and Table 14.

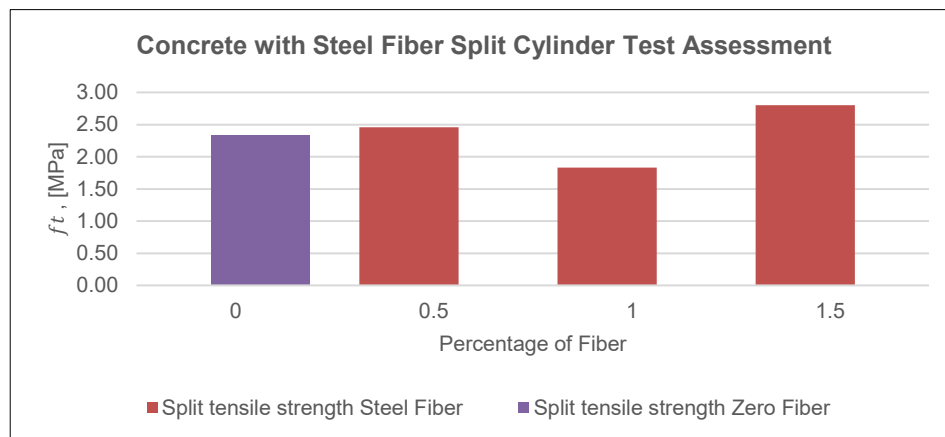


Fig. 16: Concrete's Split Tensile Strength with Steel Fiber (28 Days).

Table 14: Average Split Tensile Strength of Concrete with Steel Fiber

Name	Fiber [%]	Splitting tensile strength [MPa] [ft]	Increased percentage or decrease percentage
28 Days Concrete Age			
Controller	0	2.34	
Steel Fiber (SF)	0.5	2.46	5.128
	1	1.83	-21.795
	1.5	2.8	19.658

4 Conclusion

One of the most difficult tasks was cleaning the wool. The traditional way of cleaning the wool requires a large volume of water. In this case, finding a different way to filter the water or using specialized equipment to wash wool is essential. Because it will help stop water loss.

At the time, SWF wool had a beneficial impact on a few concrete mechanical property ranges. This will employ green materials for the concrete component and evaluate the environment to protect it.

However, at certain percentages, steel fiber also had an impact on the concrete's characteristics. This is also a highly important signal for preserving the environment and enhancing the tangible qualities.

There are glaring flaws in using goat or sheep wool that has been matured for more than a year. As a result, using wool on animals that are one year old is more successful in this experiment.

It is advised to use sheep wool as a fiber in the creation of concrete, the one-year-old SWF outperforms the other sheep. As a result, studies on SWF should begin with sheep that are six months to a year old. In addition to the fact that it is useful for safeguarding the environment from the worry of growing waste. Investigating GWF at younger ages is suggested.

Balling of the sheep wool fibers was the first of two difficulties encountered during the mixing procedure. Under the pressure of the composite mixing, the goat's carded wool fiber was collapsing.

Between the concrete sections that had crumbled, the fiber was acting as a very sturdy bridge. In the event of a structural failure, it has a highly important signal that serves as a safety measure for people.

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