Journal of
Composites Science

Article

Innovative Use of Single-Use Face Mask Fibers for the Production of a Sustainable Cement Mortar

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Abstract: Due to the COVID-19 epidemic, biomedical waste management has overwhelmed both developed and developing nations. It is now a critical issue that has to be addressed with minimal possible adverse impact on the environment. This study introduced a technique of recycling face masks into polypropylene fibers for use in concrete. This proposed recycling process provides complete disinfection of contaminated clinical waste and offers the opportunity to transform the characteristics of an end product. Microfibers manufactured from recycled medical masks were subjected to testing. According to the results, polypropylene is the primary component of this research program. Two batches of concrete were made, one with the inclusion of masks as polypropylene fibers and another that performed as a control mix. The modified mortar was compared to the control mix in split tensile, flexure, compressive strength, and water absorption. Compressive strength was found to be improved by about 17%, and tensile strength to be increased by around 22% when mask fibers were incorporated. This research introduced a novel approach for disposing of waste masks and established the preliminary viability of upcycling trash face masks towards mortar concrete production.

Keywords: cement; face mask; polypropylene; UPV; sorptivity

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Citation: Avudaiappan, S.; Cendoya, P.; Arunachalam, K.P.; Maureira-Carsalade, N.; Canales, C.; Amran, M.; Parra, P.F. Innovative Use of Single-Use Face Mask Fibers for the Production of a Sustainable Cement Mortar. *J. Compos. Sci.* **2023**, *7*, 214. https://doi.org/10.3390/jcs7060214

Academic Editors: Francesco Tornabene and Thanasis Triantafillou

Received: 28 February 2023
Revised: 15 April 2023
Accepted: 9 May 2023
Published: 25 May 2023

1. Introduction

More than half of the world countries have mandated the usage of face masks in response to the COVID-19 outbreak [1]. Indeed, India uses about 380 million face masks every day, and Asia uses over 2.2 billion [2,3]. Around 6.88 billion face masks produced every day worldwide during the epidemic of COVID-19 creates tons of plastic garbage, which threatens environmental and marine life owing to its nonbiodegradable nature [2,4]. According to estimates provided by the WHO, controlling COVID-19 would need close to 89 million masks per month [5]. Few of the masks are thrown away, burned, or buried, but most of the face masks are visible on streets, parks, and beaches due to their lightweight nature, which allows wind and water to carry them [6–8]. The most common kind of face mask is the disposable surgical type, which is made mostly of polypropylene [9–11], a material that contributes to microplastic contamination in the environment [12]. It causes major health issues for humans and the environment [13]. Thus, the circular economy concept should be encouraged in medical waste management policies, particularly for single-use face masks [14–19]. Researchers have assessed recycled face masks through various methods since the epidemic began. Most of the research has concentrated on reusing and disinfection of masks [20–24]. Waste masks were often discarded via a combination of ways rather than being processed as biomedical waste [25]. The collection and disposal of infectious trash in developing countries pose a serious threat to public health [26]. Since harmful gases (furan and dioxin) are released due to the combustion of plastics, this disposal option is not suggested for used face masks. Researchers are now facing a new challenge in properly disposing of used masks so as to minimize environmental impact [27,28]. Recycling discarded sanitary masks and reusing them as an admixture in building materials is one potential approach that might be used to address these concerns [29]. It improves certain concrete qualities while also helping the worldwide reduction in mask waste. Several researchers have experimented with incorporating masks into concrete by combining paper pulp and admixtures [30]. The waste mask was used by Rehman et al. in fat clay in order to enhance the clay's mechanical qualities [31]. In addition, researchers have investigated the possibility of using crushed fiber in the bases of roads and pavements. Fragmented face masks were included in the recycled aggregate concrete used for the subbase of the road and road base [32–34]. Face masks are made from polypropylene fibers which have a high Young's modulus and tensile strength, making them ideal for use in the concrete industry [35–39]. The addition of fibers to concrete improves its strength and durability. Concrete's qualities change depending on its composition, shape, placement, orientation, and density [40–42]. Fibers prevent shattering and breaking caused by plastic shrinkage. Optimal results are achieved by adding fibers to concrete at a volume percentage of between 0.1% and 2% [41]. Islam and Gupta tested polypropylene-fiber reinforced concrete in their research; they found that the 0.30% volume addition of polypropylene fibers decreased compressive strength by 10% over the testing period. With 0.1% polypropylene fiber by volume, splitting tensile strength increased 39%, but compressive strength decreased [43]. Xu et al. observed that cellulose fiber (CTF) doses of 1.5 kg/m^3 enhanced concrete compressive strength by 12%, whereas polyvinyl alcohol fiber (PF) dosages of 4.0 kg/m^3 decreased the strength by 35% [44,45]. CTF's splitting tensile strength decreased by 23% at the same dose, whereas PF's decreased by 55% and polyolefin fiber's decreased when the dosage was 2.0 kg/m^3 [46]. Zivanovic et al. examined structural concrete's mechanical qualities using high-density recycled polyethylene fibers (HPDE). In addition to a control mixture, tests were conducted on two different fiber diameters using HDPE that was added to the mix at volumes of 0.40%, 0.75%, and 1.25%, respectively, for each fiber diameter. It was found that the compressive strength and Young's modulus are unaffected; HPDE fibers at 0.40% and 1.25% in the concrete mix increased tensile and flexural strengths by 3% and 14%, respectively. [47]. It is also worth noting that the mix composition may need to be adjusted if fiber reinforcement is included in the concrete [48,49]. The quantity, size, and thinness of the fibers all have a role in the workability of concrete, together with the mix composition. Al-Hadithi and Hilal [50] incorporated waste plastic fibers (WPF) from plastic containers into self-compacting concrete (SCC) to study its influence behavior. WPF was added in volumetric ratios between 0% and 2% to a control mix. At 7, 14, and 28 days, flexural and compressive strengths were tested. The compressive strength of WPF was found to be greater throughout all mixes over the control mix at 7, 14, and 28 days, with compressive values of 43 and 55 MPa, 52–66 MPa, and 52–76 MPa. WPF increased flexural strength in all combination compositions [50]. Due to their reinforcing effect, virgin polypropylene fibers reduce workability and enhance tensile and flexural strength, reducing cracking. Short fiber may increase compressive strength. Durability and dimensional stability increase and controls shrink when propylene fiber is incorporated into concrete [51,52]. Polypropylene fiber improves chloride resistance and freeze-thaw resistance [53,54].

Wastes from disposable face masks can be recycled into artificial aggregates for use in the building industry, thereby limiting some of the environmental damage caused by waste disposal [55]. Every year, humankind's need for natural resources expands. The building sector consumes lots of natural resources and has a major environmental effect. As a result, making use of recycled materials to create new products is considered one of the most important steps in the journey of sustainable economic growth [56]. The decommissioning of discarded masks is a major environmental concern on a worldwide scale, and our study is an essential first step in solving this problem. In addition to this, it investigates the possibilities of recycling waste materials by including them in the manufacturing of concrete. In addition, the fiber that is added to concrete in order to improve its qualities comes at a high cost. Because of the substantial amounts of energy and carbon that are emitted during its manufacturing, the manufacture of carbon fibers is seen as environmentally destructive and expensive. Recycling discarded masks into fiber form offers a supply of fibers that may be used as building materials at a lower cost and may eventually replace the present virgin fibers. In addition, the incorporation of utilized facemasks in building materials seems to have the potential to enhance the microstructure of mortar and concrete, which would lead to an increase in the mechanical and long-term durability properties of concrete. A study conducted by Ahmed et al. [57] shows that adding single-use face mask (SUM) fibers to concrete enhances its mechanical properties, particularly the ultimate compressive strength (UCS), by 9.4% at an optimal 2% PPE volume. The fibers also contribute significantly to calculating the splitting tensile strength (STS) and flexural strength (FS) of the reinforced concrete. The effect of PPE fibers on concrete performance starts to diminish after 2% volume. Marcin et al. [58] explored the recycling of personal protective face masks into polypropylene fibers to be added to a concrete mixture. The addition of processed masks slightly increased compressive strength by 5%, did not affect frost resistance, water permeability, or fire performance, but slightly decreased tensile strength by 3%. The study showed that incorporating processed masks into concrete is a viable way to recycle them without deteriorating the concrete's properties, and further optimization and modification of PP strings are needed to improve hardened concrete properties. Wisal et al. [59] developed an ecofriendly recycling technique using waste disposable medical face masks (DMFMs) in sustainable green concrete. A new fiber hybridization approach was introduced by incorporating DMFM and basalt fibers in fiber-reinforced recycled aggregate concrete (FRAC). Test results showed an increase in compressive, split tensile, and flexural strengths of FRAC containing hybrid fibers and mineral admixtures. The water absorption rate gradually increased with an increase in the volume fractions of fibers, but it remained within the allowable water absorption limit for construction materials. The microstructure investigation indicated excellent concrete quality and good compatibility of the host concrete matrix with both DMFM and BF fibers. The study by Miah et al. [60] on recycling shredded and cut mask fibers (MF) from COVID-19 single-use surgical face masks in mortar mixes resulted in a decrease in compressive strength due to increased voids but significantly higher flexural strength. MFs also reduced shrinkage and water absorption rate, suggesting enhanced mortar durability. Proper handling of waste face masks can limit their environmental impact while providing new sustainable materials for construction.

The study found that recycled face masks can be transformed into polypropylene fibers for use in concrete, providing a way to dispose clinical waste. Incorporating mask fibers improved compressive strength by about 17% and tensile strength by around 22%. This novel approach offers a promising solution for addressing the overwhelming biomedical waste management issue caused by the COVID-19 epidemic. On the other hand, other studies, such as Ahmed et al., Marcin et al., and Wisal et al., also explored the recycling of face masks into concrete. However, they focused on different aspects, such as the optimal volume of face mask fibers for concrete, the effect of processed masks on concrete properties, and the use of hybrid fibers and mineral admixtures to improve concrete strength. These studies suggest that incorporating waste face masks into concrete can be an ecofriendly and sustainable approach to waste management while providing new materials for construction.

The novelty of this study lies in the proposed technique of recycling used face masks into polypropylene fibers that can be incorporated into concrete for construction purposes. This method not only provides a solution for the overwhelming amount of biomedical waste generated due to the COVID-19 epidemic but also offers the opportunity to transform the characteristics of the end product concrete. The study demonstrates that incorporating shredded mask fibers into concrete can improve its compressive strength by 17% and tensile strength by around 22%. Additionally, the study suggests that using waste face masks in construction does not pose any special risks, as the low pH of concrete makes it hard for the virus to survive on concrete surfaces. Overall, the study presents a novel approach for disposing of waste masks and establishes the preliminary viability of upcycling trash face masks towards mortar concrete production.

2. Materials and Methods

2.1. Materials

In this study, recycled polypropylene fibers from used face masks are incorporated into a concrete mortar. The method of recycling masks is described initially and the mortar with polypropylene fiber composition and experimental study are described in the rest of the section. It was decided to utilize 3-ply disposable face masks for this research since they are widely used and very cheap. Fabric made of spun-bond polypropylene is used for the face mask's innermost and outermost layers, while the majority of the fabric used for the mask's intermediate layer is made of melt-blown polypropylene. Polypropylene of spun-bond fibers might well be utilized in triple layers of the product in order to save costs in some circumstances. The inner layer, which is made of meltdown polypropylene, is the major substance that provides protection against contaminated particles and viruses. At the beginning of the epidemic of COVID-19, melt-blown materials were in short supply, which caused prices to rise everywhere around the globe. Either polyester or nylon is used in the production of the face mask's ear loop. Because it has a plastic foundation, the material that is used to make face masks is resistant to water as well as heat, and this property contributes to the material's overall durability. In building materials, all of these qualities are considered to be desirable.

2.1.1. Treatment of Waste Face Mask

The risk of transmission of COVID-19 from surfaces is one hundred times lower than the risk of contracting the virus directly from an infected individual [61]. According to the findings of other investigations, coronavirus may survive on plastics for up to three days and a day on cardboard [62]. Since COVID-19 is not known to survive on plastics for extended periods of time, using face masks in construction does not pose any special risks. On the other hand, the World Health Organization (WHO) suggests that a steam treatment may also be used to sterilize the masks. The low pH of concrete makes it hard for the virus to thrive on concrete surfaces. The masks were gathered together, and then they were left for a week. Masks were sprayed with an alcohol-based disinfectant to ensure their safety. The application of waste face masks as an efficient building composite material is something that researchers are investigating at the current [63]. The waste masks undergo processing that results in shredded mask fiber waste, as shown in Figure 1.

2.1.2. Slashing of Faces Masks

Shredding machines have gained popularity as an effective solution for processing large volumes of face masks and other medical waste. These machines use sharp blades or cutters to cut masks into smaller shreds. They typically feature a double shaft configuration, with two sets of blades rotating in opposite directions to ensure thorough shredding. Once the shreds are collected, they can be further processed or incorporated into other materials. For example, shredded face masks can be added to concrete to enhance its qualities. Shredding machines come in varying capacities, power requirements, and features. The Maxin Hodis Plasto—750 Dual, for instance, is a high-capacity shredding machine that can shred up to 500–1000 kg of face masks per hour. It comes equipped with a double-stage cleaner, heavyduty tapered roller bearings, a chain coupling drive, and a helical gearbox for efficient and reliable operation. Using fibers derived from trash is an effective way to contribute to sustainability and promote a circular economy, as fibers are often expensive. When incorporating face masks into concrete, fibers are crucial in enhancing their qualities. To achieve this, a specially designed shredder is used to pull fibers from the mask. The percentages of mask fibers mixed into the concrete can range from 0.5% to 2.0% of the volume of the concrete. Figure 1 shows the shredded mask fibers incorporated into the concrete mix. This not only helps to reduce waste but also promotes sustainability in the construction industry.


(**a**) (**b**)

Figure 1. (**a**) Single-used mask (**b**) Shredded mask.

2.1.3. Cement and Aggregate

For this study, we utilized regular Portland cement that met the standards of ASTM C150 [64]. Mineral and chemical compositions are shown in Table 1. The natural sand used for the fine aggregate comes from a river basin in the vicinity. Testing the materials in accordance with American standards allows for the determination of initial properties of materials such as specific gravity and fineness modulus. A specific gravity of 2.6 has been determined for fine aggregate. The sieve analysis test is used to figure out the composition of the sand, and one of its results is the fineness modulus. It has a fineness modulus of 2.9, which places it in the medium sand group. The fine aggregate falls into Zone II on the basis of the fineness modulus limitations that are specified in the international standard ASTM C 33 [65]. Figure 2 shows the particle size distribution of fine aggregate.

Table 1. Mineral composition and chemical composition of cement.

Mineral Composition			Chemical Composition							
C_3S	C_2S	C_3A	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	SO_3	Na_2O
52	22.1	8.75	20.4	6.55	3.56	1.75	65	0.54	0.42	0.25

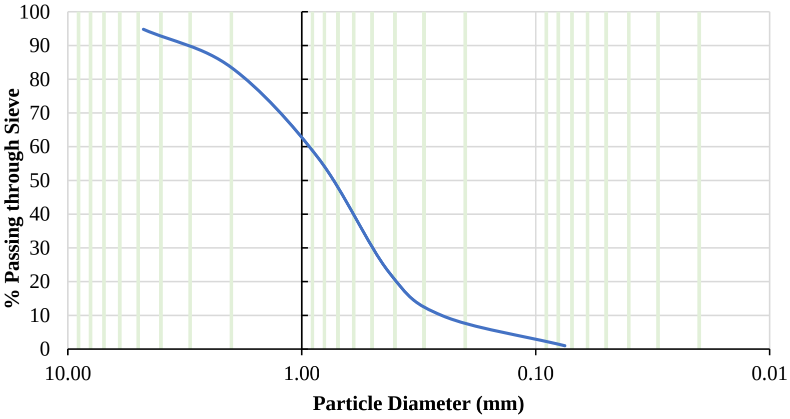

Figure 2. Particle size distribution fine aggregate.

2.1.4. Mixing and Casting

Regular Portland cement with locally accessible natural sand in a 1:2 weight ratio is used for casting the specimens. After the shredded mask fibers, cement, and sand had been dry mixed for one minute, superplasticizer (Plastiment BV-40, Sika, Baar, Switzerland) and water were added to the mixture maintaining the w/c ratio 0.4; the mix proportions are shown in Table 2. Two more minutes were spent combining the ingredients. After taking a short pause, the mixing process then continued for another two minutes as per ACI 211-91 [66]. Slump measurements for each combination came within an acceptable range (80–120 mm). For each batch of concrete, cubes, cylinders, and prisms of 50 × 50 × 50 mm, 50 × 100 mm, and 40 × 40 × 100 mm were cast. In preparation for testing, cast samples are unmolded and placed in water at room temperature in the laboratory.

Table 2. Mix proportion and workability mask fiber mortar.

S.No	Fiber Content %	Cement Weight (kg)	Sand Weight (kg)	Fiber Weight (kg)	Water Weight (kg)	Superplasticizer Weight (kg)	Workability
MF0	0	480	960	0	192	4.8	254
MF1	0.5	480	960	2.4	192	4.8	231
MF2	1	480	960	4.8	192	4.8	219
MF3	1.5	480	960	7.2	192	4.8	204
MF4	2	480	960	9.6	192	4.8	191

2.2. Methods

2.2.1. Strength Tests

The mortar cubes' sides were smoothed down using sandpaper so that the stress applied by the testing equipment would be distributed uniformly throughout the specimen's face (Figure 3). Before carrying out the tests, the specimens were removed from the curing water and allowed to dry to a saturated surface state. The procedures for conducting the tests were in line with those outlined in ASTM C109 [67]. In this test, compression testing equipment manufactured by Lawrence & Mayo was used. The rate of the application of the load was 0.6 MPa/s. Three samples were analyzed at 7 and 28 days of life.

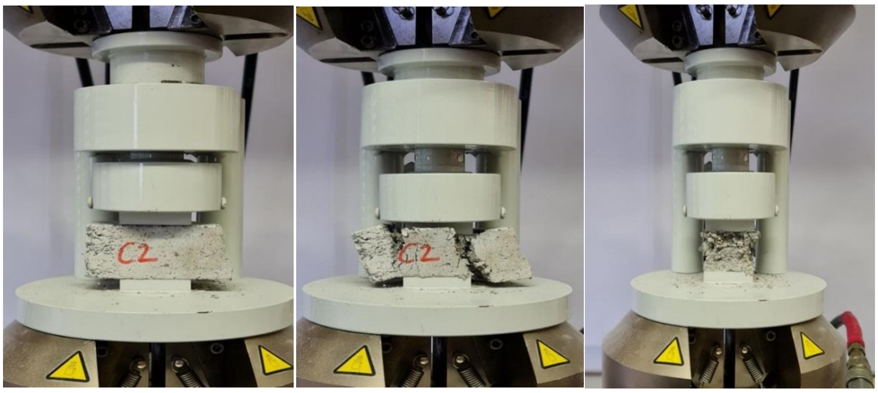

Figure 3. Compressive strength test on mask fiber mortar blocks.

Before beginning the testing process, the specimens were removed from the curing tank and allowed to reach the saturated surface dry state on their own. A minimum of 3 specimens prepared were molded from each mix. Concrete cylinders were 50 mm wide and 100 mm height. The samples were then tested on a universal testing machine (UTM) for splitting tensile strength at 7 and 28 days after being constructed (Figure 4). An evaluation of shredded mask fiber concrete's flexural strength was carried out in a manner that was compliant with ASTM 293-02 [65]. Beam specimens measuring 40 mm × 40 mm × 160 mm in thickness were subjected to a flexural strength test utilizing a UTM at 7 and 28 days after casting for comparison (Figure 5).

Figure 4. Failure of mask fiber mortar at split tensile test.

Figure 5. Flexural strength test of mask fiber mortar beam.

2.2.2. An Ultrasonic Pulse Velocity (UPV)

In order to conduct nondestructive tests on mortar samples, nondestructive studies were performed via the use of ultrasonic pulse velocity [44,45]. Measurements of ultrasonic pulse velocity (UPV) were carried out with the assistance of a commercially available handheld ultrasonic testing tool. Model 58-E4800 UPV tester with (rate of pulse 5 Hz, resolution 0.1 s, transmitter output 1200 V) is utilized. An amplifier, an electrical pulse generator, and a timing circuit were linked to a pair of transducers operating at a frequency of 150 kHz in order to measure the amount of time that elapsed between the arrival at the transducer and the beginning of a pulse that was receiving it. The following procedures were carried out in order to obtain the UPV values.

i. Each mortar cement specimen has a transmitter and receiver placed at opposing ends of the specimen (Figure 6). Then, ultrasonic pulses of low frequency are produced by this equipment.

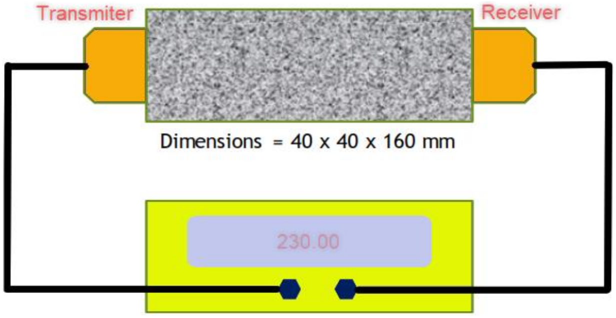

Figure 6. Schematic view of UPV test on mortar specimen arrangement.

ii. The amount of time it took for a signal to move from one transducer to the other via a sample of pulses was measured.
iii. This equation (V (km/s) = path length/transit time) was used to calculate the longitudinal ultrasonic velocities of the samples.

3. Sorptivity Test

In accordance with EN ISO 15148, the water absorption coefficient, also known as sorptivity, of the specimens was calculated using the partial immersion approach. Samples were dried and sealed with hot paraffin wax before testing. The water level was maintained throughout the measurement at a level that was about 5 mm higher than the highest point on the bottom side of the specimen (Figure 7). Capillary suction is the primary factor that contributes to the water being drawn into the concrete sample. The increase in specimen mass, denoted by the symbol Δmt, was calculated at various intervals up to 24 h and then plotted against the square root of the weighing time denoted by the symbol $\sqrt{t}$. After that, the water absorption coefficient, denoted by Ww, 24 h, was computed. It is also defined as the product of the water amount exerted by the samples per unit area and the square root of time.

Figure 7. Sorptivity test on mortar.

4. Results and Discussion

4.1. Workability

Mortar mixes can be evaluated for consistency using a flow table test. The flow test was used to calculate the quantity of water that must be added to plain mortar or fiber-reinforced mortar in order to achieve the specified consistency. The flow table that will be used in the testing of hydraulic cement was created in accordance with ASTM C1437-01 [68]. In order to achieve a typical mortar consistency, the quantity of water needed was represented as a (w/c) ratio. The impact that fibers have on the flow of mortar mixtures is seen in Table 2 and Figure 8. Adding polypropylene fiber to cement mortar significantly slows down the consistency. However, the fluidity decreases with increasing amounts of polypropylene fiber to a certain limit. In conclusion, polypropylene fiber has a negligible impact on cement mortar flow and workability.

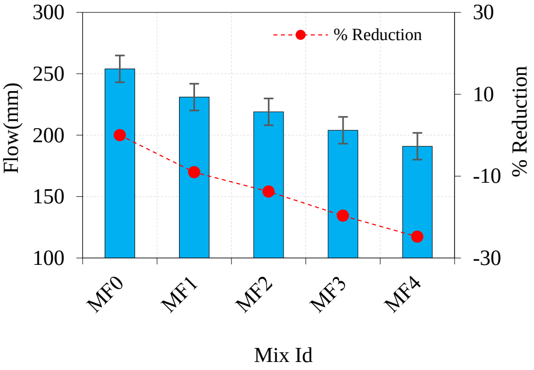

Figure 8. Workability flow test.

4.2. Compressive Strength

Results for compressive strength are shown in Figure 9. According to the results shown in the table, the mortar's compressive strength is not much improved by including fibers, but it is improved by 17% after 28 days when the shredded mask fibers have been added to the mix (MF2). The addition of 0.5% fiber content to the mix increases the mortar's compressive strength by 10.03% after 28 days compared to the same mortar without fibers. Whereas the mortar strength decreases when the fiber content increases from 1% to 1.5%, no significant changes in the compressive strength values are obtained, suggesting that fibers have no discernible effect (Figure 9). It is to be anticipated that the cement hydration of mortar samples will proceed at a leisurely pace and that the matrix will not dramatically strengthen when the mask fiber has been added more than 1%. The addition of fiber to mortar or concrete may either increase or decrease the compressive strength, depending on a number of circumstances. The fiber-to-matrix distribution is one such factor. The pore size in a matrix may be decreased by ensuring that fibers are evenly distributed throughout the mixture [69]. Because of this, the fibers enhance the energy required for microcracks to spread through the specimen, making the specimen more resistant to destruction. Because of this occurrence, compressive strength can increase. However, if the matrix is compacted highly, such as concrete of high strength with a low pore ratio, adding fibers creates pores that weaken the concrete and cause fractures [70]. Concrete strength is further weakened by fibers' softness compared to natural aggregates [71]. The plastic functions as voids in the matrix under stress, triggering the initiation of fractures around the fibers. Compressive strength is influenced by the amount to which cementitious matrix and plastic fibers adhere to one another. In summary, plastic waste strengthens concrete by creating additional voids, adhering to the cement matrix, and stopping crack openings. Polypropylene fibers added to concrete yielded comparable outcomes to this investigation. For instance, adding 1.5% and 2% polypropylene to concrete decreased compressive strength. Khatib, et al. found that concrete containing polypropylene fibers had higher compressive strength up to 2 kg/m^3 [71].

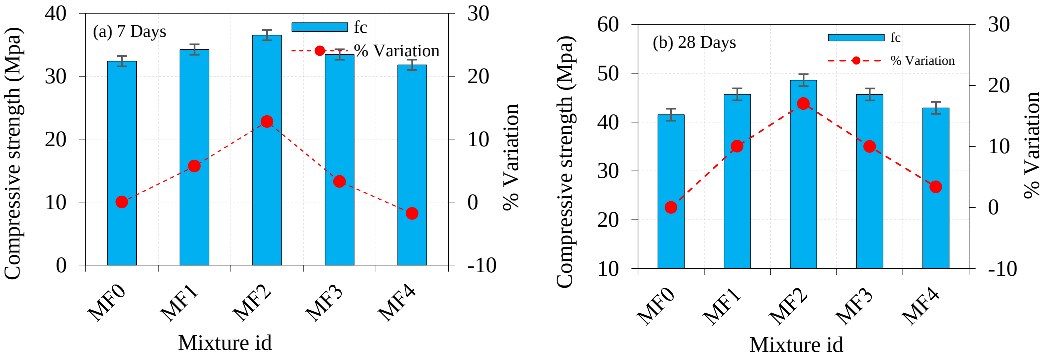

Figure 9. Compressive strength at 7 days and 28 days.

4.3. Tensile Strength

In Figure 1. the splitting tensile strength of the cement mortars is presented. It is evident that the splitting tensile strengths of the cement mortars were increased by approximately 22% by adding 1.5% of the shredded mask fiber. It is found that when compared to the control sample (Figure 10), this is a desirable result because it indicates that a mortar with a more ductile behavior can be obtained by using shredded mask fibers. In the same way, increasing the fiber content of the cement mortar up to 1.5% does not significantly lower the splitting tensile strength, but it does improve the ductility properties of the cement mortars. Increasing the percentage of mask fibers used in the mortar from 1.5 to 2% results in a reduction in the mortar's splitting strength after 28-day tests. In the scenario when there was no fiber present, an unexpected failure occurred, but there was no such failure in the scenario where there was fiber present. Figure 5 illustrates a typical failure mode for the test specimen.

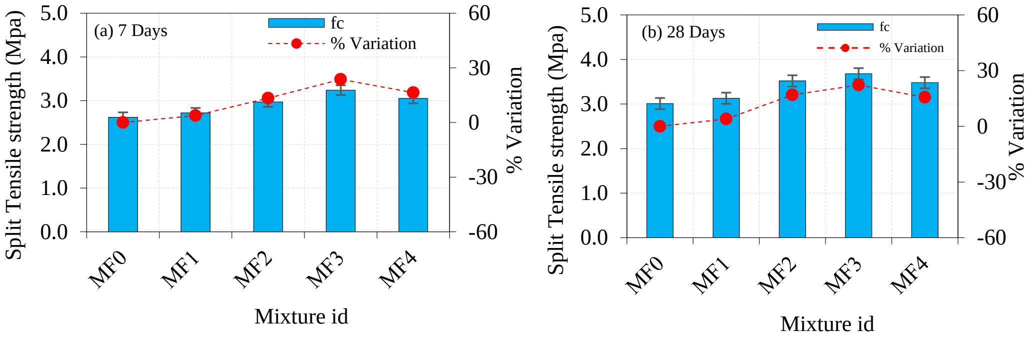

Figure 10. Split tensile strength at 7 days and 28 days.

4.4. Flexural Strength

The improvement in flexural strength due to the addition of the mask fibers is seen in Figure 11. Overall, the incorporation of shredded fibers of mask results in an increase in flexural strength when compared to the control mix mortar. It can be seen in the results that the mortar has been strengthened with shredded fibers of masks and have greater flexural strength. The rise in flexural strength does not go over 26%, even when using 1% of fibers; however, when it comes to more than 1.5%, this percentage increment in strength starts to decrease (Figure 11). Incorporating Shredded mask fibers into concrete or cement mortar has been shown to improve flexural strength in a number of different recent studies [70]. The mask pieces added to the mix also have an immense impact on the outcome of the failure. Indeed, the fibers in the sample of fiber-reinforced mortar prevent the two halves from splitting apart from one another upon cracking shown in Figure 5.

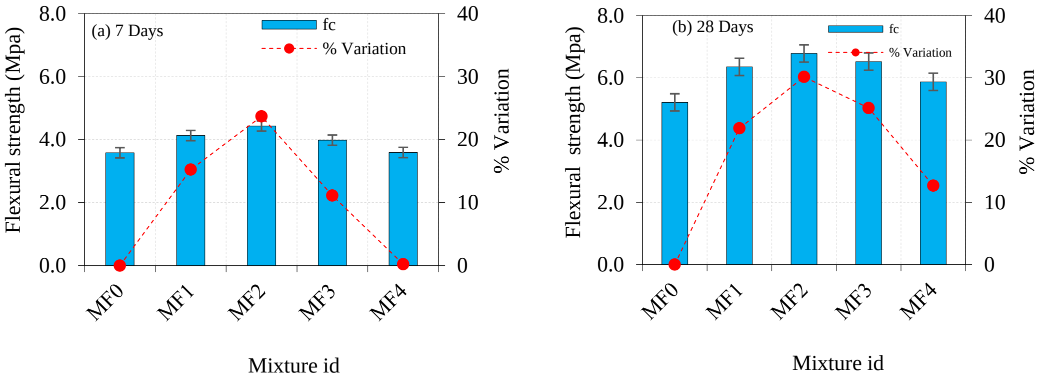

Figure 11. Flexural strength test at 7 days and 28 days.

4.5. Ultrasonic Pulse Velocity (UPV)

The UPV test results are shown in Table 3 and Figure 12. As can be observed, UPV increased continuously along with mask content by volume up until volume passed 1%, after which it slightly decreased at 1.5% and 2% volume of mask fiber. Results for compressive strength are similar to those found for the volume of mask content. UPV result showing over 4000 m/s is regarded to be concrete of good quality and of higher strength, as stated by Khatib et al. (2019) and Sims et al. (2019) [71,72]. Again, the concrete quality declined at a 1.5 percent volume rate, although it should be noted that, when compared to the control specimen, all of the mixed designs produced concrete have improved attributes. According to Yap et al. [73], if a concrete's quality falls within the aforementioned ranges, it signifies the concrete specimen has no major cracks or voids. Based on the results of the studies conducted by Shen et al. [74], it is proved that the shredded face masks added to the concrete helped to enhance its quality by decreasing the number of microfissures.

Table 3. Water absorption and sorptivity test results.

Mix. ID	Water Absorption (%)	Sorptivity (mm/$\sqrt{}$Sec)	UPV m/s
MF0	3.560	0.0225	4329
MF1	3.780	0.0238	4487
MF2	3.947	0.0256	4652
MF3	4.162	0.0272	4521
MF4	4.338	0.0289	4376

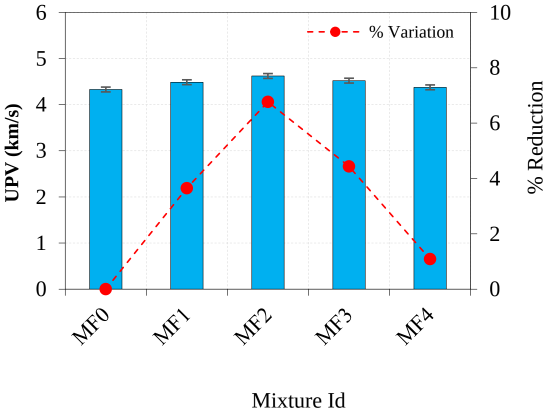

Figure 12. UPV test results on mask fiber mortar.

4.6. Sorptivity Test

The level of capillary rise in the specimens is seen in the graph of Figure 13. Specimen incorporated with mask fibers show a greater capillary rise than the reference mortar from the start of the test until 8 h. However, after 8 h, the rate of growth slows down, and the amount of this slowdown increases in proportion to the amount of mask present. Additionally, after eight hours have passed since the beginning of the test, the capillary increase remains the same for the samples that had 0.5% and 1% masks subjected. It has also been observed that the rise of water through the capillary in the specimens containing 0.5% and 1% of masks is less than that observed in the specimens containing fiber more than 1.5%. This is because the small volume of masks occupies the space in the mortar. Figure 10 illustrates the impact that the shredded mask has on capillary absorption. This is significant given that capillary absorption is a feature associated with the mask pieces. It has been discovered that the mortar that contains the mask intake more water than the mortar that serves as a control mix. The sorptivity of the different mortar mixes can be determined by utilizing the data from the capillary absorption tests, which measure the weight of water absorbed per unit area, and applying the Hall model proposed by Arunachalam et al. [75] for mortars. This method allows for the calculation of the sorptivity of the various mixtures.

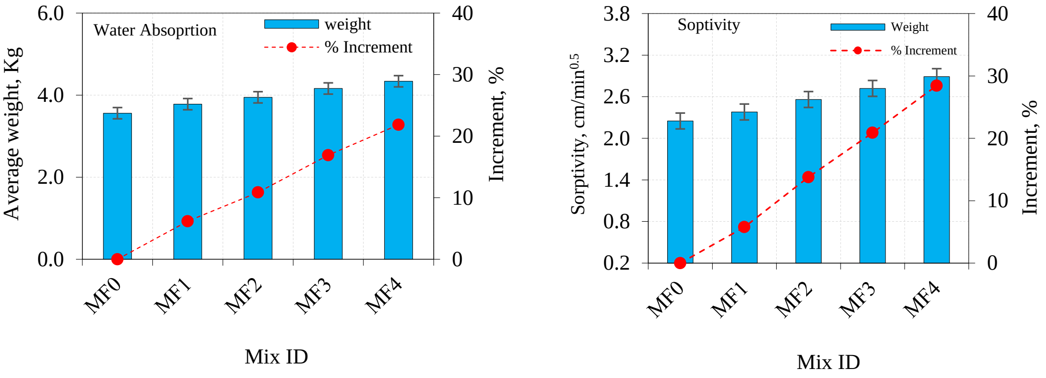

Figure 13. Water absorption and sorptivity test results on mask fiber mortar.

These two factors combined allow for the calculation of the sorptivities. Table 3 details a concise arbitrary of the findings. The increase in sorptivity that is gained by using 2% of a big mask piece is the greatest at 28%. The variance in sorptivity is substantial. The presence of mask fibers produces extra capillaries owing to the porous nature of the mask pieces, which results in an increase in the quantity of water that is absorbed. However, the presence of mask pieces enhances the sorptivity of the mortar.

5. Conclusions

The aim of this research is to determine a way to reuse the vast quantities of disposable masks that have accumulated since the start of the COVID epidemic. This is being done for two reasons: first, to address environmental contamination, and second, to enhance the cement mortar's physical and mechanical qualities. Here are the most important takeaways from this research:

- Some of the mechanical characteristics of concrete can be improved by adding shredded single-use face masks.
- The compressive strength of the samples rises by 17% when 1% of the shredded mask fiber has been incorporated in the mortar.
- When the shredded mask fiber content is added in mortar up to 1.5%, the split tensile strength of the sample specimens increases up to 22%.
- The flexural strength of the mortar beam has an increment of 30% increase in strength compared to the control specimen when 1% of the shredded mask fiber has been incorporated in the mortar.
- In comparison to the cement mortar used as a control mix, the impact of shredded mask fiber on working or flow capacity is much lower.
- As measured by the capillarity test, the mortar's sorptivity has higher, up to 28%, compared to the control specimen when 2% of the shredded mask fiber is incorporated in the mortar.
- When comparing the concrete quality made with the control mix, the UPV findings show the mortar mix manufactured using shredded face masks has a significant increment in strength. The fibers from the shredded face masks helped to reduce the number of tiny fractures in the concrete, improving the cement mortar's quality.

In conclusion, the incorporation of shredded masks in mortar has superior quality and excellent structural integrity. The use of disposable face masks in concrete manufacturing will have a significant positive effect on the environment.

Author Contributions: S.A., Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Software, Supervision, Validation, Visualization, Writing—Original draft, and Writing—Review and editing; P.C., Conceptualization, Methodology, Project administration, Supervision, Validation, Visualization, and Writing—review and editing; K.P.A., Conceptualization, Data curation, Formal analysis, Methodology, Software, Writing—Original draft, and Writing—Review and editing; N.M.-C., Supervision, Validation, Visualization, and Writing—Review and editing; C.C., Supervision, Validation, Visualization, Writing—Original draft, and Writing—Review and editing; M.A., Software, Validation, and Writing—Review and editing; P.F.P., Visualization and Writing—Review and editing. All authors have read and agreed to the published version of the manuscript.

Funding: The author thanks Vicerrectoria de Investigacion y Desarrollo (VRID) y Direccion de Investigacion y Creacion Artistica DICA, Proyecto presentado al Concurso VRID-Iniciación 2022, VRID N°2022000449-INI, Universidad de Concepción, Concepción, Chile. Centro Nacional de Excelencia para la Industria de la Madera (ANID BASAL FB210015 CENAMAD), Pontificia Universidad Católica de Chile, Vicuña Mackenna 7860, Santiago, Chile, and Dirección de Investigación de la Universidad Católica de la Santísima Concepción, Concepción, Chile.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: Special thanks for the materials provided by Alex Berg, Unidad de Desarrollo Tecnológico (UDT) de la Universidad de Concepción (UdeC) Avenida Cordillera 2634 Parque Industrial Coronel Coronel, 4191996 Biobío. Thanks for the support during the fabrication of specimens Universidad Católica de la Santísima Concepción, Concepción, Chile.

Conflicts of Interest: The authors declare no conflict of interest.

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