Possible Use for Recycled Disposable Face Masks in Concrete

Lauren Douglas
California Polytechnic State University
San Luis Obispo, CA

Disposable face masks are one of many single use products that are detrimental to the environment. The construction industry has been introducing new ways to incorporate recycled products into their materials. This paper addresses one possible way to use more environmentally friendly materials in the construction industry. 16 concrete cylinders were prepared using 4x8 forms. The mix was manipulated to test the impact of incorporating varying levels of disposable shredded face masks. Compressive strength and workability were measured in these cylinders. Eight cylinders were prepared for the control batch. Four cylinders were prepared using 10 oz. of shredded face masks and four cylinders were prepared using 30 oz. of shredded face masks. The workability for all batches was tested on day one. The compressive strength testing occurred at seven days and 28 days after the cylinders were poured. Honeycombing can be seen on most of the cylinders that include shredded face masks. The addition of shredded face masks in to the concrete resulted in a decline in workability and compressive strength. This can be overcome by decreasing the amount of shredded face mask material in each batch. Introducing plasticizer will also help increase workability of the concrete containing shredded face mask.

Key Words: Disposable face masks, Concrete, Cylinders, Workability, Compressive strength

Introduction

Concrete can be manipulated in many different aspects. Admixtures and material replacements are very commonly used. Many have experimented with introducing recycled materials into concrete batches, such as shredded rubber tires, crushed glass, or fly ash. There are numerous one-use products polluting the Earth, harming wildlife, and endangering fragile environments. These could be reduced, reused, and recycled in various construction materials.

Covid-19 Impact

The Covid-19 pandemic has increased the production and use of disposable or single-use face masks. Face masks are one of the preventative measures that is being used to slow the spread of infection. Fadare and Okoffo explain, **"**Disposable face masks (single use face masks) are produced from polymers such as polypropylene, polyurethane, polyacrylonitrile, polystyrene, polycarbonate, polyethylene, or polyester" (Fadare & Okoffo, 2020). These types of polymers are detrimental to the environment. Measures should be taken to keep these harmful pollutants out of the ocean. Fadare and Okoffo continue, "…disposable face masks (single use) that get in to the environment (disposal in landfill, dumpsites, freshwater, oceans or littering at public spaces) could be an emerging new source of microplastic fibers, as they can degrade/fragment or break down into smaller size/pieces of particles under 5 mm known as microplastics under environmental conditions" (Fadare & Okoffo, 2020). As production and consumption of face masks increases, so does the environmental danger.

Use of Waste Materials in Concrete

Today, waste materials are being used more and more in concrete to reduce the environmental impact. Fly ash, glass, and tires are a few examples of waste products that have been used in concrete. These materials pose a serious threat to the environment, so it is better that they be reused instead of trashed. There has been a lot of success with fly ash use in concrete. Fly ash is a by-product of burning coal for the generation of electricity. Studies find that "…it is possible to produce concretes with low Portland cement content, i.e. with improved environmental performance, achieving satisfactory expected compressive strength, thus being a promising alternative instead to plain cement concretes" (Teixeiraa, et al., 2016). More waste products could be used in concrete as long as they do not sacrifice the structural integrity.

Methodology

4x8 cylinders were chosen for this research. A total of 16 cylinders were cast. Each batch of concrete was tested for workability and compressive strength. Figure 1 shows the mix design for the control batch consisting of 35 lbs. of sand, 45 lbs. of coarse aggregate, 20 lbs. of Portland cement, and 10 lbs. of water. The workability of the control batch was measured by taking the slump and was measured on the day the cylinders were poured. Eight control cylinders were cast. Half of these control cylinders were labeled 7A Control, 7B Control, 7C Control, and 7D Control, and they were strength tested at seven days. The other half of the control cylinders were labeled 28A Control, 28B Control, 28C Control, and 28D Control, and they were strength tested at 28 days. Next, 10 oz. of shredded face mask waste material, as seen in Figure 2, was added to the mix. The slump was measured, and four cylinders were poured. Half of the cylinders containing 10 oz. of shredded face mask were labeled 7A 10 oz., and 7B 10 oz., and they were strength tested on day seven. The other half of the cylinders containing 10 oz. of shredded face mask were labeled 28A 10 oz., and 28B 10 oz., and they were strength tested on day 28. Then, 30 oz. of shredded face mask waste material was added to the mix design and the slump was measured. Four cylinders were cast using the 30 oz. batch. Half of the cylinders containing 30 oz. of shredded face mask were labeled, 7A 30 oz., and 7B 30 oz., and they were strength tested on day seven. The other half of the cylinders containing 30 oz. shredded face mask were labeled 28A 30 oz., and 28B 30 oz., and they were strength tested on day 28. At day seven, four control, two 10 oz., and two 30 oz. cylinders were weighed, and strength tested. At day 28, the remaining four control, two 10 oz., and two 30 oz. cylinders were weighed, and strength tested. All data was recorded, and the process was documented with pictures and notes.

Figure 1: Aggregates, Portland cement, and water for concrete mix

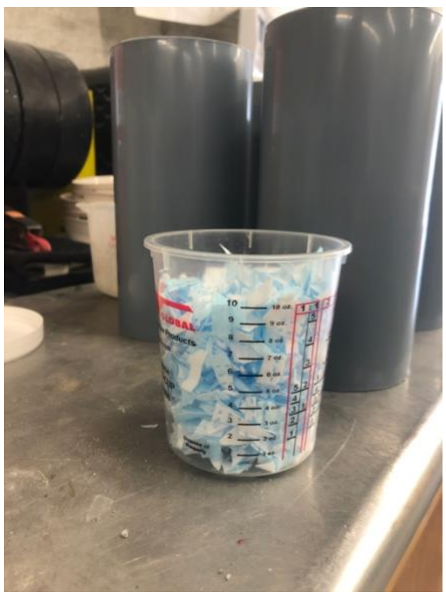


Figure 2: 10 oz. of shredded face mask

Objective

The goal of this experiment is to test the possibility of recycling a waste product in concrete. Research will show whether the waste material helps or hinders the concrete's workability and compressible strength. The waste material, disposable shredded face masks, could be beneficial to the concrete mix and performance. The fibers, plastics, and wires in the face masks could be useful in holding the concrete together, therefore making it stronger.

Workability

Concrete workability is tested by measuring how many inches fresh concrete slumps down. This is called a slump test and it follows ASTM std C143. This is performed before filling the cylinders. A slump test gives important information about the concrete, such as how easy it will be to mix, pour, and place it. If the concrete has low workability, plasticizer can be added to the mix in order to increase workability.

Strength Testing

Strength testing of the cylinders is performed at seven or 28 days. The cylinders labeled with a seven were tested on day seven and the cylinders labeled with a 28 were broken on day 28. The strength measurement is taken using a compression testing machine. The machine measures compressibility strength in units of pounds per square inch (psi). preparing cylinders for concrete compressive testing follows ASTM C31.

Data and Results

The slump was measured for each batch of concrete and each cylinder was weighed, and strength tested. The results can be seen below in Table 1. The control cylinders are the only cylinders that resulted in a slump. Cylinders 28C and 28D have the largest slump of 1.5 inches. Cylinders 7A, 7B, 7C, 7D, 28A, and 28B have a slump of one inch. All of the cylinders that contain any shredded face masks have a zero-inch slump. The average weight of the control cylinders is 8.62 lbs., the average weight of the 10 oz. cylinders is 8.505 lbs., and the average weight of the 30 oz. cylinders is 7.914 lbs. The control cylinders do not contain any face mask material, so they are heavier than the average 10 oz. cylinder and the average 30 oz. cylinder. As seen on Table 2, the average strength of the seven-day control cylinders is 3370 psi. This is significantly stronger than the average strength of the seven-day cylinders containing 10 oz. of face mask material is 2287 psi, and the average strength of the seven-day cylinders containing 30 oz. face mask material is 1087 psi. The cylinders containing shredded face mask cannot take as large of a load. The average strength of the 28-day control cylinders is 4015.5 psi, the average strength of the 28-day cylinders containing 10 oz. of face mask material is 3724.5 psi, and the average strength of the 28-day cylinders containing 30 oz. face mask material is 2262 psi. The average 28-day control cylinder is stronger in compression than the 28- day 10 oz. and 28-day 30 oz. cylinders. Overall the strongest cylinders on average are the 28-day control and the weakest cylinders are the seven-day 30 oz. The more face mask material the concrete contains, the weaker it is in compression. Honeycombing was apparent in many of the test cylinders, as seen in Figure 3. Honeycomb is a void in the concrete exposing a rough and rocky surface. It is caused by trapping air bubbles between aggregate. This can be seen in cylinders 7A Control, 7A 10 oz., 7B 10 oz., 7A 30 oz., 7B 30 oz., 28B Control, 28A 10 oz., 28B 10 oz., 28A and 28B 30 oz.

Cylinder	**Weight (lbs.)**	**Strength (psi)**	**Slump (in.)**
7A Control	8.215	2303	1
7B Control	8.660	4173	1
7C Control	8.760	3417	1
7D Control	8.680	3587	1

28A Control	8.580	4603	1
28B Control	8.625	4455	1
28C Control	8.680	3587	1.5
28D Control	8.760	3417	1.5
7A 10 oz.	8.440	2122	0
7B 10 oz.	8.575	2452	0
28A 10 oz.	8.490	3755	0
28B 10 oz.	8.515	3694	0
7A 30 oz.	7.895	1365	0
7B 30 oz.	7.580	809	0
28A 30 oz.	7.925	2017	0
28B 30 oz.	8.255	2507	0

Table 1: Data and results

Batch	**Average Strength (psi)**	**Average Slump (in.)**
Control 7 day	3370	1
10 oz. 7 day	2287	0
30 oz. 7 day	1087	0
Control 28 day	4015.5	1.25
10 oz. 28 day	3724.5	0
30 oz. 28 day	2262	0

Table 2: Data comparison table

Figure 3: Cylinder 7A and 7B 30 oz before strength testing

Conclusion

Recycling single use and disposable face masks in concrete has a positive environmental impact. It prevents the creation of micro plastics resulting from the face masks and protects the health of the environment and wildlife. The cylinder containing 10 oz. of shredded face mask is stronger than the cylinder containing 30 oz. of shredded face mask. Honeycombing in the cylinders could be the result of using aggregate that is too large for the small. Incorporating fibers and wires from shredded face masks produce varied results. Variability caused by the masks could be problematic. This variability could also be partially from the weather impacts and human error. On the day all of the cylinders were poured, San Luis Obispo, CA was under a heat advisory with dry conditions. The concrete began to dry very quickly after it was mixed. This could have contributed to the low slump seen in many cylinders. One can assume with real life application the concrete containing 10 oz. or 30 oz. of shredded face masks will be very difficult to mix, pour, and place. The finished product will likely have honeycombing and loss of homogeneity. This experiment should be redone multiple times using the same methodology.

Appendix A


10 oz. shredded face mask


Water, coarse aggregate, fine aggregate and Portland cement


Slump test for Control batch


Concrete mixture for 10 oz cylinders


Slump test for 10 oz. face mask batch

Cylinders 7A and 7B Control before strength testing

Cylinder 7A Control after strength testing

Cylinder 7B Control after strength testing


Cylinder 7A and 7B 10 oz. before strength testing

Cylinder 7A 10. oz after strength testing

Cylinder 7B 10 oz. after strength testing


Cylinder 7A and 7B 30 oz. before strength testing

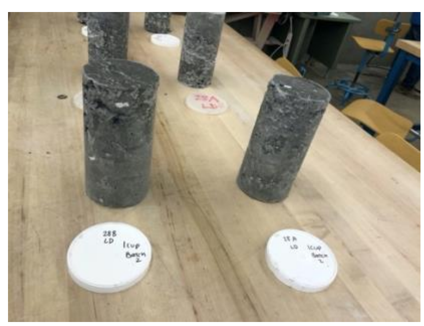
Cylinder 7A 30 oz. after strength testing
testing

Cylinder 7B 30 oz. after strength

Cylinder 28A and 28B Control before strength testing

Cylinder 28A Control after strength
testing

Cylinder 28B Control after strength testing



Cylinder 28A and 28B 10 oz. before
strength testing

Cylinder 28A 10 oz. after strength testing

Cylinder 28B 10 oz. after strength testing

Cylinder 28A and 28B 30 oz. before strength testing

Cylinder 28A 30 oz. after strength testing

Cylinder 28B 30 oz. after strength testing

Cylinder	Weight (lbs.)	Strength (psi)	Slump (in.)
7A Control	8.215	2303	1
7B Control	8.660	4173	1
7C Control	8.760	3417	1
7D Control	8.680	3587	1
28A Control	8.580	4603	1
28B Control	8.625	4455	1
28C Control	8.680	3587	1.5
28D Control	8.760	3417	1.5
7A 10 oz.	8.440	2122	0
7B 10 oz.	8.575	2452	0
28A 10 oz.	8.490	3755	0
28B 10 oz.	8.515	3694	0
7A 30 oz.	7.895	1365	0
7B 30 oz.	7.580	809	0
28A 30 oz.	7.925	2017	0
28B 30 oz.	8.255	2507	0

Table of data and results

Batch	Average Strength (psi)	Average Slump (in.)
Control 7 day	3370	1
10 oz. 7 day	2287	0
30 oz. 7 day	1087	0
Control 28 day	4015.5	1.25
10 oz. 28 day	3724.5	0
30 oz. 28 day	2262	0

Data comparison table

References & Appendix

Ali, E. E., & Al-Tersawy, S. H. (2012). Recycled glass as a partial replacement for fine aggregate in self compacting concrete. *Construction and Building Materials*, *35*, 785-791. doi:10.1016/j.conbuildmat.2012.04.117

Aragaw, T. A. (2020). Surgical face masks as a potential source for microplastic pollution in the COVID-19 scenario. *Marine Pollution Bulletin, 159*, 111517. doi:10.1016/j.marpolbul.2020.111517

Fadare, O. O., & Okoffo, E. D. (2020). Covid-19 face masks: A potential source of microplastic fibers in the environment. *Science of The Total Environment, 737*. doi:10.1016/j.scitotenv.2020.140279

Rahman, M. T., Mohajerani, A., & Giustozzi, F. (2020). Recycling of Waste Materials for Asphalt Concrete and Bitumen: A Review. *Materials, 13*(7), 1495. doi:10.3390/ma13071495

Teixeira, E. R., Mateus, R., Camões, A. F., Bragança, L., & Branco, F. G. (2016). Comparative environmental life-cycle analysis of concretes using biomass and coal fly ashes as partial cement replacement material. *Journal of Cleaner Production, 112*, 2221-2230. doi:10.1016/j.jclepro.2015.09.124