EVALUATING THE PERFORMANCE OF CONCRETE MADE USING SURGICAL MASK AS FIBRE REINFORCEMENT

Shrawani Suryawanshi[1], Sakshi Akhade[2], Trupti Kolate[3], Dr.G.C.Chikute[4]

[1]UG Student, Department of Civil Engineering, AISSMS College of Engineering, Pune, India

[2]UG Student, Department of Civil Engineering, AISSMS College of Engineering, Pune, India

[3]UG Student, Department of Civil Engineering, AISSMS College of Engineering, Pune, India

[4]Assistant Professor, Department of Civil Engineering, AISSMS College of Engineering, Pune, India

Abstract: Single-use surgical masks are commonly used in healthcare facilities for infection control during surgical procedures, patient care, and general protection against respiratory droplets. The improper disposal of used face masks introduces non-biodegradable plastic waste that will take hundreds of years to decompose, proving to be a threat to the environment. However, this difficulty presents a chance for innovation and sustainability in the building sector. The idea of using old surgical masks as reinforcing fibres in concrete is explored as it presents a fresh method of waste management and material improvement. The masks are cut and prepared by removing the ear loops and inner nose wire, then mixed into four different concrete mix designs at varying volumes (0.10%, 0.20%, and 0.30%). This research focuses on evaluating the potential benefits and applications of using these masks in concrete. Tests conducted include measuring compressive strength, split tensile strength, flexural strength to assess the overall quality of the concrete. With the addition of up to 0.1% fibre, concrete experiences enhancements in tensile, flexural, and compressive strengths by 10%, 7.5%, and 8% respectively as compared to conventional concrete. Introducing 0.2% mask leads to improvements in compressive, flexural, and tensile strength by 12.5%, 11%, and 15% respectively. Nevertheless, after surpassing the 0.20% threshold, the trend of strength increase starts to diminish. The addition of single-use face masks resulted in improved strength properties and overall quality of the concrete samples.

1. Introduction: Surgical masks, often called as medical face masks, are disposable material that are used to cover the mouth and nose of patients, healthcare providers, and other people in a variety of settings in order to stop the transmission of respiratory droplets. Disposable face masks are manufactured using non-woven polypropylene fabric. Two different fabrics (i.e., spun-bond polypropylene and melt-blown polypropylene) are used as raw materials for surgical and non-surgical face masks [1,2]. Although these masks are essential for maintaining public health, their widespread disposal has serious negative effects on the environment. The degradation of surgical masks in marine environments can release microplastics and harmful chemicals into the water, endangering aquatic ecosystems and biodiversity. Microplastics can bioaccumulate in marine organisms, potentially entering the food chain and posing risks to human health. A single disposable mask release around 1.5 million microplastic particles by weathering action [3]. The disposal of surgical masks in landfills contributes to environmental degradation, pollution, and ecosystem disruption, highlighting the need for sustainable waste management practices, while incineration can reduce the volume of waste and mitigate the spread of pathogens, it also has significant environmental consequences, including air pollution, greenhouse gas emissions, and potential contamination of soil and water resources. However, this difficulty presents a chance for innovation and sustainability in the building sector. The idea of using old surgical masks as reinforcing fibres in concrete is explored in this introduction, which presents a fresh method of waste management. Concrete is strong and adaptable, but with time it can break and deteriorate, especially when subjected to tensile stresses. To lessen these weaknesses, traditional reinforcement techniques like steel bars or fibres have long been used. Surgical masks, on the other hand, offer a special chance to improve the mechanical qualities of concrete while simultaneously addressing the urgent problem of medical waste management. By combining sustainability and structural performance, the use of surgical masks as reinforcing fibres in concrete signifies an evolution in material engineering. Surgical masks are useful for reinforcement applications because of their inherent properties. Typically, they are made of polypropylene and other synthetic fibres. These fibres function as micro-reinforcements when scattered throughout the concrete matrix, preventing cracks from spreading and enhancing the strength of concrete.

2. Materials:

2.1. Cement: It is a fine grey powder. It is mixed with water and materials such as a crush sand, aggregates to make concrete block. The ordinary Portland cement contains two basics ingredients namely argillaceous and calcareous. OPC 53 cement confirming to IS 8112 was used for casting cubes and for all concrete mixes. The cement was of uniform colour i.e. grey with a light greenish shade and was free from any hard lumps.

2.2. Fine Aggregates: The fine aggregates used for experimental program was locally procured crush sand confirming to IS383-1970.The aggregate were sieved through a sieve of 4.56mm.

2.3. Coarse Aggregates: The aggregates retained on IS sieve 4.56mm were used.

2.4. Water: Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contains marine life also usually suitable. When it is suspected that water may contain sewage, mine water, or wastes from industrial plants it should not be used in concrete unless taste indicate that it is satisfactory. Water from such sources should be avoided since the quality of water could change due to low water or by intermittent discharge of harmful wastes into the stream. Portable tap water is used for casting.

2.5. Surgical mask: Surgical masks are made of polypropylene material which is a type of fibre made from thermoplastic polymer.

Physical properties	Value	Standard
Specific gravity	0.91	ASTM D792
Tensile strength at break (MPa)	2.97	ASTM D638
Aspect ratio	24	-

Table 1: Tabular representation of physical properties of single use surgical mask

3. Methodology:

3.1. Cutting of mask: The masks were trimmed with a width of 0.5 cm and a length ranging from 2 to 3 cm. The masks were incorporated at a rate of 0.1%, 0.2% and 0.3 % of concrete volume.

3.2. Mix proportion:

- M25 grade concrete
- Mix ratio: 1:1:2
- W/C ratio: 0.44
- Exposure condition: Moderate

Materials	Cube	Cylinder	Beam
Volume	0.0033 M^3	0.0053 M^3	0.016 M^3
1.5 times	0.005 M^3	0.008 M^3	0.025 M^3
Cement	1.82 kg	2.88 kg	8.64 kg

Sand	7.37 kg	2.9 kg	8.7 kg
Aggregate	4.23 kg	6.6 kg	20.01 kg
Water	0.8 litre	1.26 litre	3.8 litre
Admixture	15 ml	25 ml	58 ml

Table 2: Mix proportion

3.3. Compression Test: The compression test is carried out on specimen cubical in shape of the size 150×150×150 mm. The test is carried out in the following steps: First, the mould preferably of cast iron is used to prepare the specimen of size 150×150×150mm. During the placing of concrete in the moulds it is compacted with the tamping bar with not less than 35 strokes per layer. Then these moulds are placed on the vibrating table and are compacted until the specified condition is attained. After 24 hours the specimens are removed from the moulds and immediately submerged in clean fresh water. After 28 days the specimens are tested under the load in a compression testing machine. The compressive strength is given by:

3.4. Split tensile strength test: The concrete mixture is poured into an oiled mould in 5 cm layers, compacted manually by a tamping bar with a minimum stroke of 30 for each layer. Strikes penetrate the underlying layer, and a rod is applied to the entire depth of the bottom layer. The top layer is compacted, and the concrete surface is levelled with a trowel. A glass or metal plate is then applied to prevent evaporation.

1. Casted specimens stored at 27°C +/- 2°C for 24 +/- 0.5 hours, marked, and submerged in water.

2. For design, specimens cured for 28 days

3. Wet specimens taken after 28 days of curing, water wiped, and diametrical lines drawn on ends for alignment.

4. Recording weight and dimensions, setting compression testing machine, and placing specimen with aligned lines.

5. Applying load continuously until breaking, noting the breaking load (P).

3.5. Flexural strength test:

1. Cast specimens using 150mmX150mmX700mm mould, applying lubricant to the mould sides.

2. Filling one third of the mould with concrete, compacting with a tampering rod for 25 blows. Repeating for the next two-thirds of the mould, compacting each layer.

3. Removing excess material, smoothening the surface with a trowel, and allowing specimens to harden for 24 hours after casting.

4. Demoulding the concrete beams, transfering to a water curing tank, and cure for specified periods (28 days).

5. Checking flexural strength by removing beams from the curing tank, removing moisture, and allowing specimens to harden at room temperature.

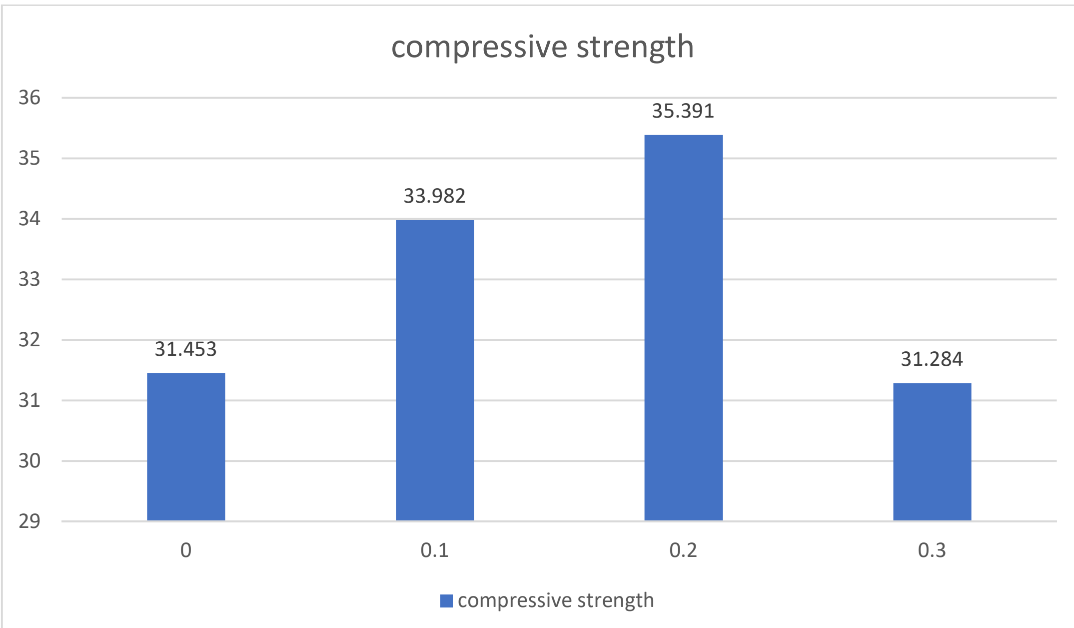
6. Marking points on the specimen, place a test block with a 20cm distance between supports, and applying load until the specimen breaks.

4. Results:

4.1. Compressive Strength: Increasing the fibre content to 0.1% and 0.2% in the mix enhances the compressive strength of concrete by 8% and 12.5% respectively but when the fibre content reaches 0.3%, the compressive strength decreases.

Sr no	% of mask	28 days compressive strength (N/mm^2)
1	0	31.453
2	0.1	33.982
3	0.2	35.391
4	0.3	31.284

Table 3. Tabular representation of 28 days compressive strength

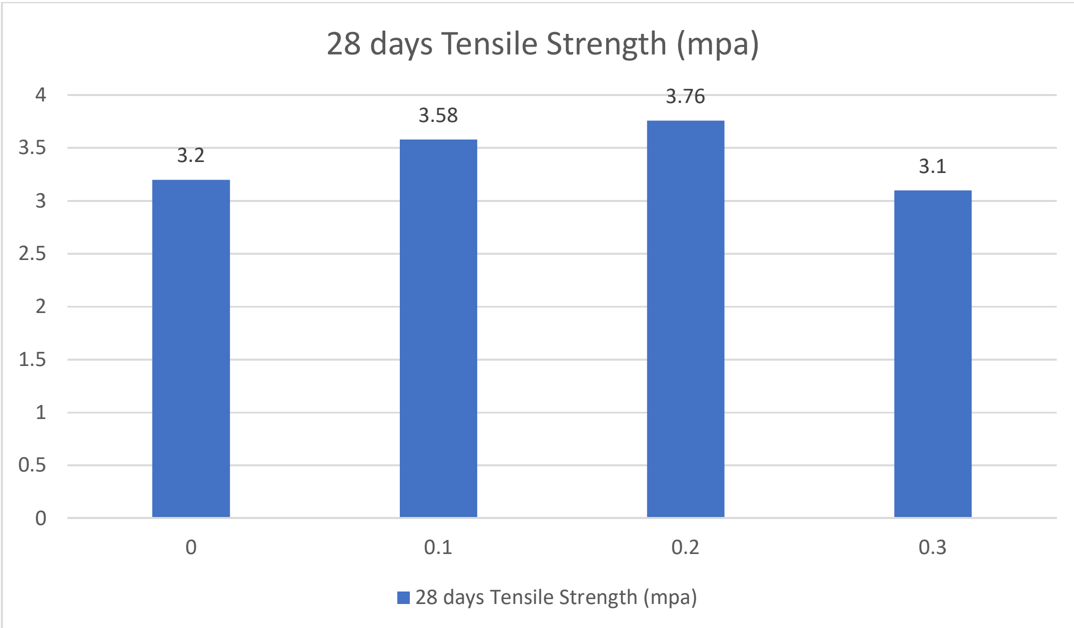


Graph 1: Graphical representation of 28 days compressive strength

4.2. Tensile Strength: Adding 0.1% and 0.2% of shredded mask fibre clearly enhances the split tensile strength of concrete. The tensile strength of concrete is increased by 10% and 15% for 0.1% and 0.2% addition respectively. However, by increasing the mass fibre percentage by 0.3% the tensile strength starts decreasing.

Sr No	% of Mask	28 days tensile strength (N/mm^2)
1	0	3.26
2	0.1	3.58
3	0.2	3.76
4	0.3	3.32

Table 4: Tabular representation of 28 days Tensile strength

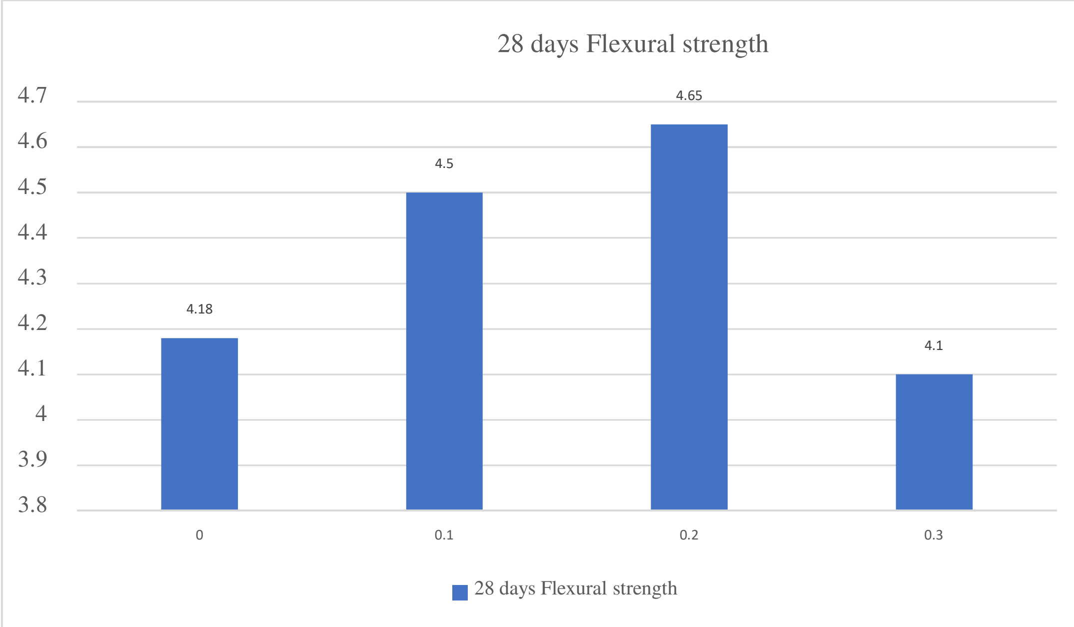


Graph 2: Graphical representation of 28 days Tensile strength

4.3. Flexural strength: An increase in flexural strength occurs when 0.1% and 0.2% of fibres are added. But strength starts to decrease at 0.3%. the flexural strength of concrete is increased by 7.5% and 11% for 0.1% and 0.2% addition respectively.

Sr No	% 0f Mask	28 days Flexural strength (N/mm^2)
1	0	4.18
2	0.1	4.5
3	0.2	4.65
4	0.3	4.1

Table 5: Tabular representation of 28 days flexural strength



Graph 3: Graphical representation of 28 days Flexural strength

5. Conclusion:

1. When up to 0.1% fibre is added, concrete's tensile, flexural, and compressive strengths improve by 10%, 7.5%, and 8%, respectively.

2. The inclusion of 0.2% mask led to an increase in compressive, flexural and tensile strength by 12.5%, 11% and 15% respectively.

3. However, beyond 0.20%, the trend of increasing strength began to decrease.

Therefore, incorporating mask fibres at 0.2% of the concrete volume proved to be the optimal percentage for improving mechanical properties.

References:

1. Ammendolia, J.; Saturno, J.; Brooks, A.L.; Jacobs, S.; Jambeck, J.R. 2021. ‘An emerging source of plastic pollution: Environmental presence of plastic personal protective equipment (PPE) debris related to COVID-19 in a metropolitan city’ Environment Pollution, volume 269, 116160.
2. Aragaw, T.A. 2020. ‘Surgical face masks as a potential source for microplastic pollution in the COVID-19 scenario’ Marine Pollution Bulletin. Volume 159, 111517.
3. Wang, Z.; An, C.; Chen, X.; Lee, K.; Zhang, B.; Feng, Q. 2021. ‘Disposable masks release microplastics to the aqueous environment with exacerbation by natural weathering’ Journal of Hazardous Material Volume 417, 126036.

4. ASTM D792 – 20 Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
5. ASTM : D638 – 14 Standard Test Method for Tensile Properties of Plastics
6. Shannon Kilmartin-Lynch, Mohammad Saberian, Jie Li, Rajeev Roychand, Guomin Zhang. 2021. 'Preliminary evaluation of the feasibility of using polypropylene fibres from COVID-19 single-use face masks to improve the mechanical properties of concrete' Journal of Cleaner Production, Volume 417, 126036
7. Shannon Kilmartin-Lynch, Mohammad Saberian, Jie Li, Rajeev Roychand,Guomin Zhang. 2021. 'Preliminary evaluation of the feasibility of using polypropylene fibres from COVID-19 single-use face masks to improve the mechanical properties of concrete' Journal of Cleaner Production, Volume 296, 126460.
8. Marcin Koniorczyk, Dalia Bednarska, Anna Masek, Stefan Cichosz. 2022. 'Performance of concrete containing recycled masks used for personal protection during coronavirus pandemic' Construction and Building Materials, Volume 324, 126712.
9. Jhanvi Sunil Sabhnani, Syed Ibrahim Ali, Kristoffer Jan and Vidya. 2023. 'Sustainable disposal of face masks in concrete: an investigation of mechanical properties and environmental impact' E3S Web of Conferences 405, 04005.
10. Marina Farrel Côrtesa, Evelyn Patricia Sanchez Espinozaa, Saidy Liceth Vásconez Nogueraa, Aline Alves Silvab. 2021. 'Decontamination and re-use of surgical masks and respirators during the COVID-19 pandemic' International Journal of Infectious Diseases, Volume 104.
11. Siva Avudaiappan, Patricio Cendoya, Krishna Prakash Arunachalam, Nelson Maureira-Carsalade. 2023. 'Innovative Use of Single-Use Face Mask Fibers for the Production of a Sustainable Cement Mortar' Journal of composite science.
12. Dasari Charishma, Pottapenjara Deronika, Syed Viqar Malik. 2019. 'Study the effect of polypropylene fiber in concrete' JETIR, Volume 6, Issue 5.
13. Archana P1, Ashwini N Nayak, Sanjana R Nayak, Harshita Vaddar, Dinesh S Magnur. 2017. 'Study of Strength of Polypropylene Fiber Reinforced Concrete' International Journal of Engineering Research & Technology, Volume 6, Issue 6.
14. Julia Blazya, Rafał Blazyb. 2021. 'Polypropylene fiber reinforced concrete and its application in creating architectural forms of public spaces' Case Studies in Construction Materials, Volume 14.