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# Use of Recycle Facemask as A Filler Material for Interlocking Tile Pavement Block Composite

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***Abstract***

*The research's primary objective is to address the waste issue resulting from the increased use of face masks. It does so by developing a pavement made from recycled face masks. The goal is to produce an interlock block by mixing face masks with cement while maintaining a cost-effective approach. In this research five design concepts are proposed for 3-point bending apparatus and then evaluated them using screening and scoring criteria to identify the most promising ones. To visualize and ensure the safety of the chosen concept, a 3D model is developed using SolidWorks software. This model is used for conducting essential calculations through both manual calculations and ANSYS analysis to verify the design's integrity and reliability. Subsequently, a prototype of a three -points bending apparatus is manufactured, and composite specimens are prepared for testing. These tests are conducted to validate the properties of the proposed composite specimens, ensuring they meet the required standards. The results indicate that adding 1.5% fiber to the concrete produces the best Modulus of Rapture (MOR). The testing demonstrates an average maximum force and MOR of 524.82 N and 0.447 MPa, respectively. The chosen concept and materials yield positive results, paving the way for a sustainable solution to address the waste issue caused by the increased use of face masks.*

**Keywords:** Interlock Tile Composites, Three-point Bending, Sustainability, Face Mask, Recycle

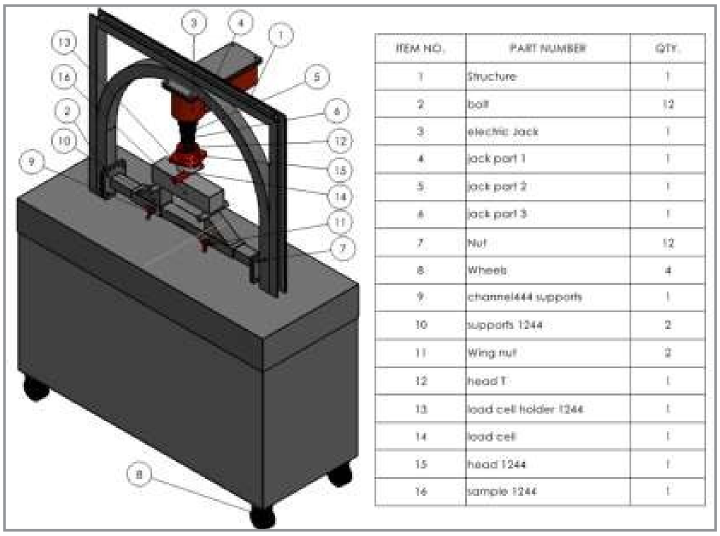
## Introduction

The Sultanate of Oman has a great interest in protecting the environment, combating pollution, and protecting wildlife through the enactment of laws and legislations to protect the vocabulary of natural life and by creating governmental institutions that are concerned with managing and preserving biodiversity in the Sultanate. Oman's Environment Authority (EA) has implemented its decision to ban single-use plastic shopping bags in the country, effective 1 January 2021. With the ban on single- use plastic carry bags, outlets had already procured alternatives made from cloth and paper to serve customers 2021 [1]. The emergence of the novel coronavirus (COVID-19) disease has attracted global attention since December 2019, and beyond the demand for protective equipment has increased rapidly. This measure has led to an increase in the amount of waste. Many researchers and institutes have paid attention to this topic to reduce the impact of these wastes on the environment through recycling them or developing new methods of managing them. 2020 proposed an innovative Internet of Things IoT-based smart recycling machine as one of the feasible solutions to consolidate the collection and sterilization methods before moving to the next recycling steps from public area to manufacturing recycling plant. 2020 examined the most diffused type of disposable face mask and identifies the characteristic of the constituent materials through morphological, chemical, physical, and thermal analyses [2, 3]. They concluded the recycle material from facemask can use in the applications of material not subjected to shocks or significant deformations but able to withstand loads (e.g., furniture or other domestic appliances). A series of experiments, including modified compaction, unconfined compression strength and resilient modulus tests, were conducted on the blends of different percentages of the shredded face mask (SFM) added to the recycled concrete aggregate (RCA) for road base and subbase applications, 2021 [4]. They concluded Overall, the blends of the waste materials (i.e., RCA and SFM), as a low carbon concept, satisfied the stiffness and strength requirements for pavements base/subbase; therefore, can be used as a viable and alternative base/subbase material. For example, 1% of SFM is added to RCA to make 1 km of a two-lane road with a width of 7 m and a thickness of 0.5 m for base and subbase, approximately 93.2 tons of SFM would be required, i.e., preventing 3 million used face masks from ending up in landfills. 2020 wrote a report about Binish Desai's who incorporated a recycle facemask brick production [5]. The brick is stronger and more durable, which makes it three times stronger than conventional bricks at twice the size and half the price and it is fire retardant, recyclable and absorbs less than 10% water. 2013 fabricated and tested concrete polypropylene paver block composite [6]. They concluded that by addition of polypropylene fibers in paver block it increases the compressive strength of paver blocks and reduces the maintenance cost of paver block. Also, it's helpful to improve the life span of paver block. According to 2022 mixing processed masks with the concrete resulting in a marginal enhancement of compressive strength (approximately 5%) and a slight reduction in tensile strength (around 3%). Furthermore, the inclusion of processed masks was found to have no discernible impact on material properties associated with the durability of concrete, such as frost resistance, water permeability, and fire performance [7]. As per the findings by Idrees 2022, the optimal dosage for enhancing both compressive and tensile strength, reducing chloride permeability, and improving freeze-thaw resistance was determined to be 1% by volume of waste mask fibers [8]. Additionally, the utilization of 0.5% crushed mask fiber was identified as effective, particularly in the production of concrete characterized by lower permeability and heightened durability. 2022 Investigated the effect of shredded face mask fibers as an additive to hot mix asphalt (HMA) to the rutting resistance of the asphalt [9]. They concluded that, the mixes with 0%, 0.25%, 0.50%, 0.75%, 1.0%, 1.25%, and 1.5% face mask fiber meet the requirements of hot mix asphalt mixing standard.

## Materials and Methods

### Design Process of Three – points Bending Apparatus

Various methods are employed in the generation of engineering specifications, with one of the most effective and widely adopted approaches being Quality Function Deployment (QFD) as described by 2010. This involves establishing specifications or objectives for the product, aligning them with customer desires, evaluating how competitors meet these goals, and setting numerical targets for achievement [10]. The subsequent phase involves Design Concept Generation, wherein diverse designs are created to embody the team's ideas. A comparative analysis of these designs is then undertaken to identify the most optimal solution. Five distinct design concepts were formulated, comprising essential components such as a three-point bending arrangement fixture, structural elements, a hydraulic actuator with load cell, and a force indicator. Following the creation of design concepts, the process moves to Concept Selection, typically executed in two stages to simplify the evaluation of product concepts. The initial screening stage involves a rapid, approximate assessment to narrow down viable alternatives. Subsequently, a more detailed analysis, involving scoring, is employed to evaluate the relatively few remaining concepts. The screening process, guided by selected criteria aligned with customer needs, facilitates the identification of the most suitable concept for further development. The selection criteria, including factors like cost-effectiveness and efficiency, guide the assignment of relative scores such as "better than" (+), "same as" (0), or "worse than" (–) to assess each concept's performance against the reference concept. Upon the completion of the screening process, one concept is chosen for advancement, and the subsequent phase involves delving into the design details to determine the dimensions of critical project components and ensure safety compliance. Figures 1 and 2 depict the SolidWorks modeling and fabricated prototype of the final three points bending apparatus, respectively.



| ITEM NO. | PART NUMBER | QTY. |
|---|---|---|
| 1 | Structure | 1 |
| 2 | bolt | 12 |
| 3 | electric Jack | 1 |
| 4 | jack part 1 | 1 |
| 5 | jack part 2 | 1 |
| 6 | jack part 3 | 1 |
| 7 | Nut | 12 |
| 8 | Wheels | 4 |
| 9 | channel444 supports | 1 |
| 10 | supports 1244 | 2 |
| 11 | Wing nut | 2 |
| 12 | head T | 1 |
| 13 | load cell holder 1244 | 1 |
| 14 | load cell | 1 |
| 15 | head 1244 | 1 |
| 16 | sample 1244 | 1 |

**Figure 1:** Three-point bending SolidWorks Model

**Figure 2:** Final Prototype

**Interlock Composite Specimen**

To prepare specimens, careful considerations must be made. The molds should ideally be uniform in size, and the composition of the mixture should be consistent across all samples, with the exception of the varying fiber percentages. To achieve this, Table 1 was referenced to determine the appropriate proportions of water, cement, and sand for the mixture. A mixing ratio of 1:3 was adopted. The percentage composition of each component was calculated as follows: cement accounted for 18.86% of the total weight, sand comprised 66.04%, and water constituted 15.09%. To estimate the maximum weight of the interlock, considering dimensions and a density of 2.4 g/cm3, each sample was projected to weigh 4 kg. As three samples were intended for each fiber ratio, one mixture weighed a total of 12 kg. Consequently, the amount of cement required, based on the percentage of cement weight in the total mixture, was 2.4 kg, while sand and water amounted to 8 kg and 1.8 kg, respectively. The mixing process started with varying percentages of fiber. The 12 kg mixture is designed to yield three samples, each representing a distinct fiber percentage. Initially, the mixture (12 kg) was prepared, and masks were incorporated at a rate of 1.5%, as depicted in Figure 3. Subsequently, the blended mixture was poured into three molds. In the second phase, a new mixture was created, incorporating 3% of masks, as illustrated in Figure 3. Finally, a mixture without any added masks (0%) was concocted and cast into a mold. All molds were then left undisturbed for a period of 7 days to ensure thorough drying of the specimens before testing. Wooden molds were designed in the distinctive shape of the letter "L," as depicted in Figure 4. This design choice was motivated by the challenge of consistently producing molds of identical size. By adopting molds in the shape of an "L," this approach affords a means to regulate dimensions during the casting of the mixture. Figure 5 shows molded composite specimens.

**Table 1: Mix ratios and material proportion 2023[11].**

| Mixing Ratios | Cement (kg) | Quarry dust (kg) | Granite chipping (kg) | Water |
|---|---|---|---|---|
| 1:4 | 13.91 | 64.93 | - | 11.13 |
| 1:3 | 17.39 | 60.87 | - | 13.91 |
| 1:2 | 23.19 | 54.11 | - | 18.55 |
| 1:1:2 | 17.39 | 40.58 | 32.61 | 13.91 |
| 1:2:4 | 9.94 | 46.38 | 37.27 | 7.95 |
| 1:1.5:3 | 12.65 | 44.27 | 35.58 | 10.12 |

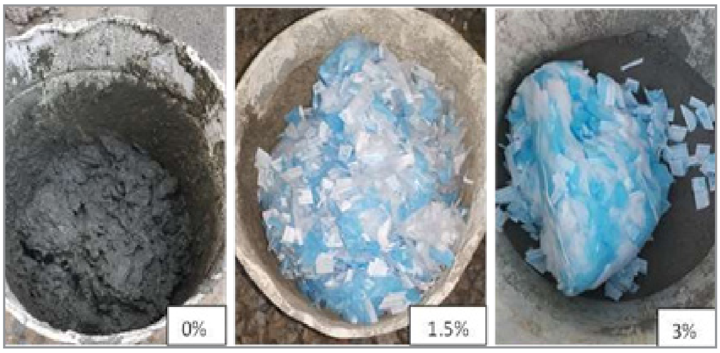



**Figure 3:** Cement fiber composite

**Figure 4:** Wooden Mold

**Figure 5:** Composite specimens

## Results and Discussions

In Figure 6, the variation in samples density with fiber percentage is illustrated. It is evident that as the fiber percentage increases within the sample, there is a significant and noticeable decrease in density. This phenomenon suggests the potential to produce lightweight interlock pavement. Figure 7 shows the average maximum bending force for all fiber ratios, as it shows that the addition of fiber has a major role in increasing the material's durability. Figure 7 shows the extent to which the samples can withstand the applied force, as 0% of the fibers were the weakest, then 3%, and the strongest among them was 1.5%. The same pattern observed in Figure 8 for MOR is reflected in the fiber percentage data. The highest MOR value for fiber percentage was 1.5%, whereas the lowest value corresponded to the fiber percentage of 0%.

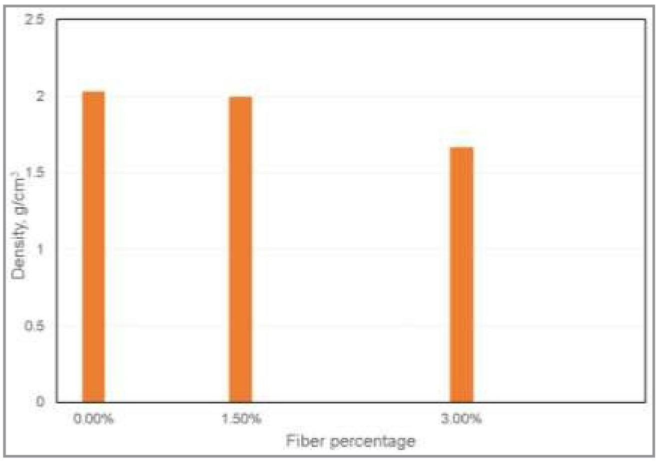



**Figure 6:** Variation of sample density with fiber percentage

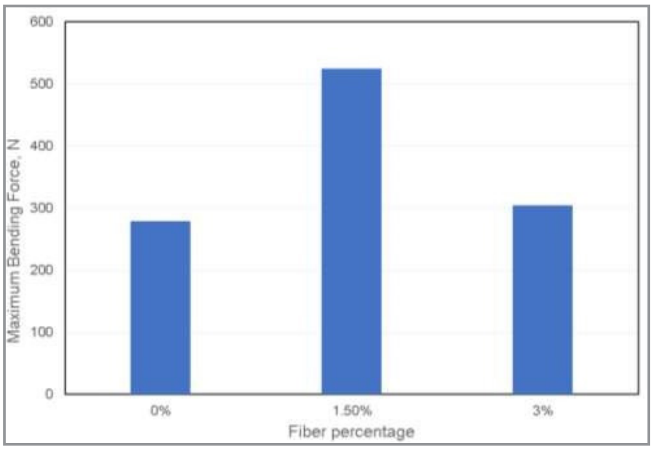



**Figure 7:** Maximum bending force

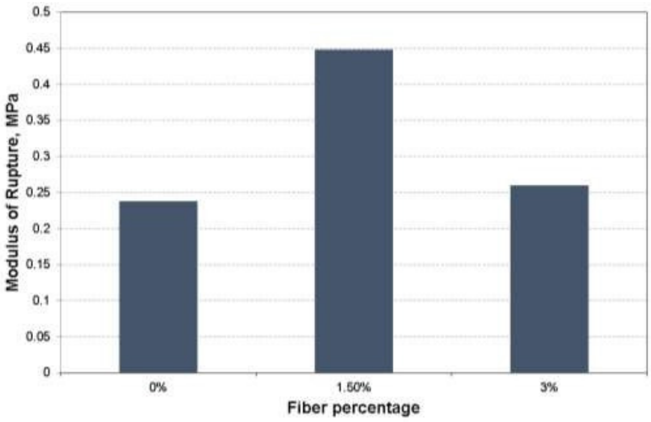



**Figure 8:** Variation of Modulus of Rupture, MOR with fiber percentage

Figure 9 illustrates the fracture characteristics of composite specimens. It is evident that the specimen with zero percent fibers undergoes brittle fracture when compared to the composite specimen. Thus, it can be concluded that incorporating fibers into the concrete enhances both the ductility and damping properties of the pavement block.


**Figure 9:** Fracture of composite specimens

## Conclusion

Composite blocks were created by integrating recycled fibers from face masks with concrete, and a specially designed 3-point bending apparatus was constructed for testing these blocks. The tests were conducted to validate the properties of the proposed composite specimens, ensuring their compliance with the required standards. The following conclusions were drawn:

1. A fiber content of 1.5% resulted in a significantly high Modulus of Rapture of 0.447 MPa.
2. The incorporation of fibers into the concrete improved both the ductility and damping properties of the pavement block.

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