

# Sustainable Geopolymer Bricks in Incorporating Recycled Mask Waste

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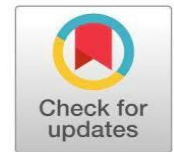
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**Abstract:** With the advent of the COVID-19 pandemic, the global consumption of single-use surgical masks has risen immensely, and it is expected to grow in the coming years. Simultaneously, the disposal of surgical masks in the environment has caused plastic pollution, and therefore, it is exigent to find innovative ways to handle this problem. In this study, surgical masks were processed in a laboratory using the mechanical grinding method to obtain recycled surgical masks (RSM). The RSM was added in doses of 0%, 1%, 2%, 3%, and 4% by volume of geo polymer bricks, which were synthesized with ground granulated blast furnace slag (GGBS), rice husk ash (RHA), sand, and sodium silicate( $\text{Na}_2\text{SiO}_3$ )atambientconditionsforadurationof28 days. The developed bricks were tested for compressive strength, flexural strength, density, water absorption, efflorescence, and drying shrinkage. The results of the study reveal that compressive strength and flexural strength improved with the inclusion of RSM in the bricks. The highest values of compressive strength and flexural strength were 5.97MPa and 1.62MPa for bricks with 4% RSM, respectively. Further, a reduction in the self-weight of the bricks was noticed with an increase in RSM. There was no pronounced effect of RSM on the water absorption and efflorescence properties. However, the RSM played a role in reducing the drying shrinkage of the bricks

**Keywords:** M–Sand, GGBS, Mask, Alkline Activeter, Water

## 1. INTRODUCTION

The emergence of the COVID-19 pandemic has led to an escalation in the consumption of single-use surgical masks due to better health care expenditure and increase in respiratory protection. According to a recent market analysis report, the trade of surgical masks is expected to expand at a compound annual growth rate of 5.1% from 2022 to 2030. Which is an indication of the growing use of surgical masks in the coming years. The use of surgical masks greatly reduced the spread of COVID-19 disease; however, its negative environmental impact due to improper handling and disposal becoming a wide spread concern. Surgical masks are typically made of polypropylene (PP) and other plastic products, which are manufactured by chain-growth polymerization and processed thermally to fit the required products . The PP masks are made of three fabric layers, which are the outer non-woven fabric, a middle melt-blown fabric, and an inner soft fiber layer similar to the outer layer. According to Prataet al. During the COVID-19 pandemic, approximately 129 billion single-use face masks were disposed of every month across the globe, and as per Nghiemetal. All these PP masks represent more than half a million 14 tons of PP waste in the world. Further, in the first two years of the pandemic, at least 4 million tons of improperly handled PP waste from personal protective equipment would have been released into the environment. The PP waste released from surgical masks will cause a serious ecological hazard. Because PP masks are made of fibers and these materials disintegrate into secondary micro plastics at a higher rate compared to other plastic products such as bags and boxes. Additionally, PP mask micro plastics can persist in the environment for upto 450 years.

## II. MATERIAL USED

1. Surgical masks (polypropylene fibers)
2. Fly ash
3. Ground granulated blast furnace slag (GGBS)

4. Alkaline activator (NaOH, Na<sub>2</sub>SiO<sub>2</sub>)
5. Water



### III. PROPOSED METHODOLOGY ARCHITECTURE FLOWCHART:

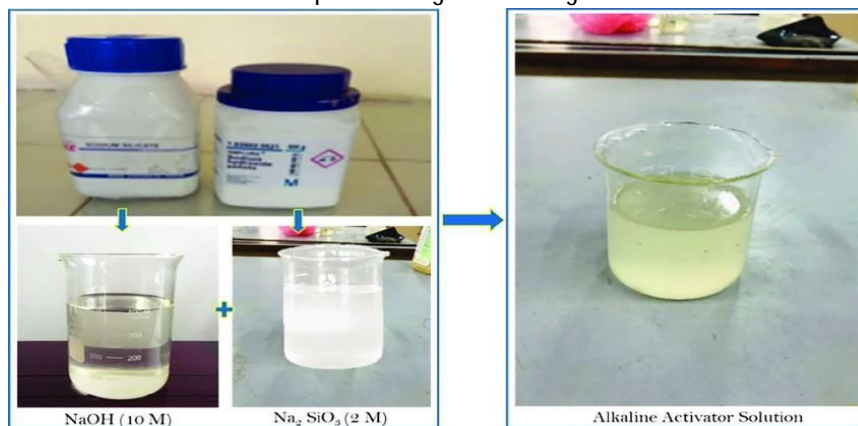
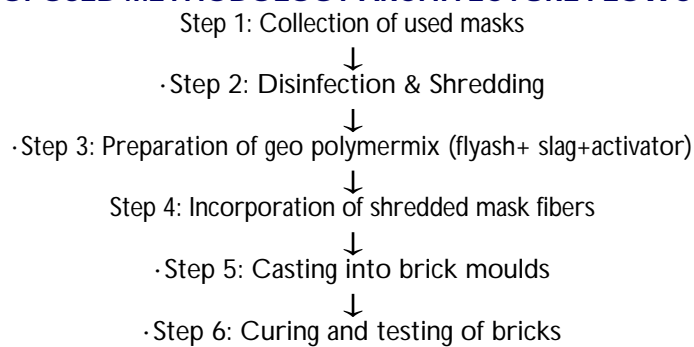


Fig.-1

### 4. EXPERIMENTAL INVESTIGATION

This experimental investigation is to study the feasibility of incorporating recycled mask waste into geo polymer bricks and evaluate their mechanical and durability properties. The study focuses on determining how mask fibers affect compressive strength, water absorption, and overall performance of the bricks.

- a. Dry materials such as fly ash and sand were mixed thoroughly.
- b. Shredded mask fibers were added to the dry mix.

- c. Alkaline activator solution ( $\text{NaOH} + \text{Na}_2\text{SiO}_3$ ) was prepared separately.
- d. The solution was slowly added to the mixture and mixed uniformly.
- e. The mixture was poured into brick molds.
- f. The molds were compacted and leveled.
- g. Bricks were cured at room temperature or in an oven for 24–48 hours.

## RESULTS AND DISCUSSION

### 1. Compressive Strength

- The control brick (0% mask waste) showed normal compressive strength.
- Bricks with 0.5%–1% mask fibers showed a slight improvement in strength due to fiber reinforcement.
- When mask content exceeded 1.5%, the compressive strength slightly decreased due to increased voids in the mixture.

### 2. Water Absorption

- a. All brick samples showed water absorption within acceptable limits.
- b. Bricks with mask fibers showed slightly higher water absorption compared to the control sample.

### 3. Density

- A. The addition of mask fibers reduced the overall density of the bricks.
- B. This resulted in lighter bricks, which can be beneficial for construction.

### 4. Crack Resistance

Mask fibers helped reduce micro-crack formation.

Bricks showed improved flexibility and toughness.

### 5. Optimum Mask Content

The best performance was observed when about 1% recycled mask fibers were added to the geo polymer brick mixture.

## INTRODUCTION OF BASIC INGREDIENTS

### A. Fly Ash

Fly ash is a fine powder by-product obtained from the combustion of pulverized coal in thermal power plants. It is rich in silica ( $\text{SiO}_2$ ) and alumina ( $\text{Al}_2\text{O}_3$ ), which are essential for geopolymerization.

**Role:** Acts as the primary source material for geopolymerization, providing aluminosilicate content.

### A. Ground Granulated Blast Furnace Slag (GGBFS)

GGBFS is a by-product from the iron and steel manufacturing industry, obtained by quenching molten slag in water. **Role:** Acts as a supplementary binder with high calcium content, improving early strength gain. **Advantages:** Enhances durability, reduces permeability, and improves resistance to chemical attacks. **Chemical Composition:** Contains  $\text{CaO}$ ,  $\text{SiO}_2$ , and  $\text{Al}_2\text{O}_3$ . **Function in Bricks:** Improves setting time, compressive strength, and binding efficiency in geopolymer mixtures.

### B. Alkaline Activators (Sodium Hydroxide & Sodium Silicate)

- These solutions initiate the geopolymerization process by dissolving aluminosilicate materials (from fly ash and slag).
- Sodium Hydroxide ( $\text{NaOH}$ ): Breaks down the aluminosilicate structure to release reactive silica and alumina.

**Sodium Silicate ( $\text{Na}_2\text{SiO}_3$ ):** Promotes polymerization and strengthens the gel network. **Function in Bricks:**

Together, they form the geopolymer gel ( $\text{N-A-S-H}$  and  $\text{C-A-S-H}$ ) responsible for binding particles and providing mechanical strength.

- **Typical Ratios:** The  $\text{Na}_2\text{SiO}_3/\text{NaOH}$  ratio is commonly.

**C. Recycled Mask Waste** Recycled mask waste primarily consists of polypropylene (PP), a thermoplastic polymer that is light weight, flexible, and durable.

**Source:** Collected from single-use face masks after proper disinfection and shredding.

**Role:** Acts as a partial replacement for fine aggregates or filler material in geopolymer bricks.

### D. Fine Aggregates (Sand)

Fine aggregates, typically river sand or manufactured sand, are used to provide bulk and dimensional stability to the bricks.

**Role:** Fills voids between geopolymer paste and improves workability.

**Advantages:** Ensures uniform texture and shape in finished bricks.

**Function in Bricks:** Controls shrinkage and enhances compactness.

### E. Water

Water is essential for preparing the alkaline activator solution and ensuring proper mixing of ingredients.

**Role:** Facilitates dissolution of  $\text{NaOH}$  pellets and helps in uniform mixing.

**Note:** Excess water should be avoided as it can weaken the geopolymer material.

### Mixing and Compatibility

**Poor Bonding:** Polypropylene (PP) fibers from masks are hydrophobic and may not bond well with the hydrophilic geopolymer matrix, affecting strength and uniformity.

**Uneven Distribution:** Achieving uniform dispersion of shredded mask fibers in the mix can be challenging, which may lead to weak zones in the brick.

**Need for Additives:** Sometimes coupling agents or surfactants are required to improve adhesion, increasing cost and complexity. Mixing and compatibility issues refer to problems that occur when two or more substances, materials, or chemicals are combined and do not interact properly with each other. These problems can lead to undesirable chemical reactions, reduced effectiveness of products, formation of unwanted compounds, damage to equipment, or safety hazards.

Therefore, understanding compatibility is important before mixing any materials in industries such as agriculture, pharmaceuticals, chemical manufacturing, food processing, and construction. Process of combining two or more substances to produce a uniform and homogeneous mixture. In many industrial and scientific processes, mixing is essential to ensure proper distribution of components and to achieve the desired product quality. For example, mixing fertilizers, pesticides, medicines, chemicals, or construction materials like cement and sand. Compatibility refers to the ability of two or more substances to be mixed together without causing harmful reactions, loss of stability, or reduction in effectiveness. Compatible substances remain stable when combined, while incompatible substances may react chemically or physically.

#### ENVIRONMENTAL IMPACT:

**Reduction in Plastic Pollution: Recycling of Mask Waste:** The project helps address one of the most pressing environmental issues of the post-COVID era the accumulation of non-biodegradable mask waste.

**Composition of Masks:** Single-use masks are primarily made of polypropylene (PP), which can take hundreds of years to decompose.

**Environmental Benefit:** By reusing shredded mask waste in geo polymer bricks, this project diverts large volumes of plastic waste from landfills, incineration, and marine pollution. Efforts to reduce plastic pollution include the use of biodegradable or eco-friendly materials, reusable products, and strict regulations on single-use plastics. Recycling also plays a major role in preventing plastic waste from entering the environment. Public awareness and responsible consumer behavior are equally important in reducing plastic use. Reducing plastic pollution helps to protect natural ecosystems, conserve marine life, improve environmental quality, and promote sustainable development. Therefore, adopting environmentally friendly practices and reducing dependence on plastic materials are essential steps toward maintaining a cleaner and healthier planet.

**Mix Design Based on reference:** Example mix proportions (adapt to your material densities): Binder: GGBS (85 % by weight of binder) +RHA(15%) (as in the study) Sand: 30 % by weight of solid fraction (in that study) Alkaline activator: sodium silicate solution (for example ~8 % by weight of solid fraction) + water(~10%)

**Mask waste (RSM):** varied at 0%, 1%, 2%, 3%, 4% by volume of brick (or relative to total solid) as in the study. You may choose similar or refine: e.g., 0%,2%,4%, 6% by volume or weight of solids depending on preliminary trials. Also consider adjusting and / binder ratio or activator concentration.

#### CONCLUSION

Incorporating recycled surgical mask waste into sustainable geopolymers bricks is a promising innovation that addresses both environmental pollution and the demand for eco-friendly construction materials. This innovation not only provides a sustainable alternative to conventional bricks but also offers a scalable solution to manage pandemic-related plastic waste. It exemplifies how interdisciplinary engineering combining materials science, environmental sustainability, and civil construction can lead to impactful real world solutions.

#### REFERENCE

1. Here are credible references for your academic project on sustainable geopolymers bricks using recycled mask
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