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# Investigation of the Rheological Characteristics of Asphalt Modified from Medical Mask Waste Fibers

I Gusti Agung Ananda Putra<sup>\*,1</sup>, I Nyoman Arya Thanaya<sup>2</sup>, I Made Agus Ariawan<sup>3</sup> & Yenni Ciawi<sup>4</sup>

<sup>1,2,3,4</sup> Doctor of Engineering Program Study, Universitas Udayana, Indonesia.

<sup>1</sup>Environmental engineering, Universitas Pendidikan Nasional, Indonesia.

## Corresponding Author:

I Gusti Agung Ananda Putra

Email: [putra.2291011002@student.unud.ac.id](mailto:putra.2291011002@student.unud.ac.id)

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**Abstract:** Masks are essential for preventing people from breathing in dangerous compounds and airborne pollutants. On the other hand, incorrect mask disposal presents a serious environmental risk. Medical masks are mostly made of polypropylene and are formed of three layers: a central layer of melt-blown material, an outer layer of waterproof non-woven fabric, and an interior layer. This research aims to determine the effect of medical mask waste fiber on the rheological characteristics of asphalt. In terms of the rheological characteristics of asphalt, the addition of asphalt will decrease the penetration, ductility, specific gravity, and lost on heating, and increase the viscosity, softening point, and flash point. The positive impact is that the inclusion of mask waste results in increased asphalt hardness, enhancing resistance to rutting. On the other hand, the negative impact is that the inclusion of masking waste will reduce the resistance to cracking due to the reduced elasticity.

**Keywords:** Medical Mask, Polypropylene, Rheological, Asphalt Modified

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## 1. Introduction

The global impact of COVID-19 epidemic has created serious health problems, finances, and the environment worldwide [1]. Personal Protective Equipment (PPE) usage has experienced a notable surge during the ongoing pandemic compared to pre-pandemic periods [2]. A crucial measure in combating the spread of the virus is the widespread adoption of medical masks. One effective way to fight the [3], contributing to a projected 20% annual growth in the supply of medical masks from 2020 to 2025 [4]. The daily global consumption of disposable masks has reached approximately 6.8 billion, underscoring the widespread reliance on this

protective measure [5]. Studies indicate that mask usage can provide up to 90% protection against the virus, emphasizing the effectiveness of this preventive measure [6]. However, the environmental impact of medical mask disposal poses a significant concern [7]. Balancing the necessity of using medical masks with the environmental consequences of their disposal remains a critical challenge in the ongoing fight against the pandemic.

Disposable masks, categorized as personal protective equipment, pose a significant environmental threat if not handled through sustainable practices such as recycling or

proper reuse [8]. Due to their lightweight composition, wind and rain have the power to scatter abandoned masks composed of easily moveable materials, leading to their ubiquitous presence in urban areas, parks, parking lots, and local surroundings. This widespread disposal issue, in turn, contributes to the contamination of rivers and oceans, posing a severe hazard to marine life [9]. Disturbingly, estimates indicate that nearly 0.15-0.39 million tons of discarded masks enter the ocean annually, jeopardizing the survival of marine ecosystems [10]. According to Fauzi [11], In the context of Indonesia, alarming data from March 2020 to July 2021 reveals the generation of a substantial 18,460 tons of Covid-19 waste, signifying a considerable and concerning environmental impact. The escalating consumption of non-biodegradable materials raises apprehensions, with predictions suggesting that by 2050, the volume of plastic in the oceans may surpass that of fish [12]. Conventional disposal techniques, such as high-temperature incineration, worsen environmental degradation by releasing hazardous gases and accelerating global warming [13]. Opting for landfills as a disposal solution introduces soil pollution, as the decomposition of mask waste is an enduring process, taking hundreds of years [14]. Therefore, addressing the environmental impact of mask disposal demands urgent attention and sustainable strategies to mitigate the growing threat to ecosystems and public health.

While the current use of masks is on the decline, a survey conducted by Dihni [15], reveals that people continue to use masks for various reasons. Among the respondents, 75% cited protection against air pollution and unpleasant odors as a primary motive, while 69% wore masks to guard against the transmission of other viruses. Additionally, 64% of respondents expressed the use of masks specifically to prevent the spread of Covid-19. Other reasons included long-term habituation, with 62% stating they had been using masks for an extended period, and 50% mentioning increased comfort as a factor.

Various types of masks are crucial for public awareness, including medical masks, cloth masks, and N95 masks, each designed for specific purposes. Medical masks are composed of three layers-spunbond, a meltblown filter, and another layer of spunbond-to effectively prevent the transmission of particles. Contrarily, cloth masks require three layers: an outside layer composed of the same hydrophobic material

(polypropylene), an inner layer composed of hydrophilic materials (cotton), and a middle layer composed of hydrophobic materials (polypropylene). N95 masks have four to five layers and are well-known for their excellent filtering effectiveness. The outer and middle layers are typically composed of polypropylene, with the middle layer incorporating polypropylene electret. The inner layer commonly features cotton. Notably, in studies exploring the use of medical mask materials, especially polypropylene, in asphalt production, the entire constituent layer of medical masks is utilized. Polypropylene's characteristics, including a high melting point of 165°C, a thin, soft surface, and good resistance, absorbency, and strength make it suitable for short-term use at temperatures up to 100°C ([16]. In general, the mask exhibits a semi-liquid state within the temperature range of 115.5 to 160°C, aligning with the hot asphalt mixture and paving temperatures. This characteristic allows it to serve as an adhesive, effectively adhering to the aggregate during the asphalt construction process [17]. Medical masks, mostly made of plastic made of polypropylene known for its slow decomposition, can serve as an alternative in asphalt mixes. Leveraging the material's elastic properties, ideal for use as adhesives, offers a potential solution to address challenges associated with the disposal of medical masks [18]. Polypropylene is typically used to make medical masks, which has thermoplastic qualities and is comparable to asphalt, the main component of road pavement [19]. Asphalt, derived from natural sources formed over millions of years, is considered a non-renewable resource [20]. In light of this, recycling discarded medical masks emerges as a viable solution, presenting an opportunity to repurpose them as reinforcements for building materials [21].

Given that special processing processes are required for mask waste generated from healthcare settings, it is feasible to separate mask fibers from residential activities [22]. Considering that the coronavirus can only survive for five minutes at 70°C [23], and the process of producing, transporting, and implementing asphalt takes at least 30 minutes, keeping the temperature of the asphalt between 120 and 150°C. Asphalt mixing normally takes place at temperatures between 150 and 180°C, it is anticipated that the coronavirus would be entirely eradicated during these stages.

The possibility of integrating medical mask trash into road pavements has been investigated by researchers [24].

This study aims to assess the impact of medical mask waste fibers on the rheological properties of asphalt, contributing valuable insights into potential applications and implications for the utilization of mask waste in road construction.

## 2. Methodology

This research was carried out at the Highway Laboratory of the Department of Civil Engineering, Udayana University. In conducting this research using two stages of research, namely the preparation stage and the testing stage. For more details, the two stages of research will be explained one by one as follows:

### 2.1. Initial Phase

The Preparatory Phase of this study includes the preparation of materials and the preparation of testing equipment. The materials used in this study were 60/70 penetration asphalt and medical mask waste fibers obtained from household waste. For used mask waste, it is necessary to sterilize it first using an oven at a temperature of 70°C for 1 hour, then the metal strip of the nose and ear loop is removed from the mask before use. Then, the medical mask is cut according to a predetermined size, after which the crushing stage is carried out using a shredder / shredder machine and the result is in the form of mask fibers that become small fragments. The equipment used in this study is basic rheological properties testing equipment, namely penetration tools, viscosity, soft point, ductility, flash point, asphalt specific gravity, and asphalt weight loss.

### 2.2. Testing Phase

The testing phase consists of two stages, the first is to make a mixture of 60/70 penetration asphalt and mask fiber with variations in levels of 0%, 1%, 2%, and 3% against the weight of asphalt. The steps for mixing asphalt and fiber masks are as follows:

1. The asphalt is heated until it melts with a temperature of 150°C for 30 minutes.
2. Pour the mask fiber flakes into the melted asphalt little by little.

Stir using a mixer for 40 minutes at 170 °C so that the mask fibers and asphalt are evenly mixed.

## 3. Result and Discussion

### 3.1. Asphalt Testing Result

The results of 60/70 penetration asphalt testing at the Highway Laboratory of the Department of Civil Engineering, Udayana University are summarized in Table 1. From the results of the initial inspection, it is known that the entire data obtained meet the requirements / specifications of asphalt required for use in paved mixtures.

Table 1. Testing Result of 60/70 Penetration Asphalt

No	Test Type	Testing Method	Specification	Testing
				Result
1	Penetration, (0,1 mm)	25°C SNI 2456:2011	60-70	66.7
2	Kinematic Viscosity (cSt)	135°C SNI 7729:2011	≥ 300	335
3	Softening Point, °C	SNI 2434:2011	≥ 48	48.5
4	Ductility at 25°C, (cm)	SNI 2432:2011	≥ 100	150
5	Flash point (°C)	SNI 2433:2011	≥ 232	328
6	Specific gravity	SNI 2441:2011	≥ 1.0	1.031
7	Weight Lost (%)	SNI 06-2441-19 91	< 0.8	0.31%

### 3.2. Asphalt Testing Result with Modified of Fibers from Discarded Medical Masks

The results of testing the properties of 60/70 penetration asphalt that has been added with medical mask waste fiber based on the percentage by weight of asphalt are summarized in Table 2.

Table 2. Asphalt Testing Result with Modified of Fibers from Discarded Medical Masks

No.	Test Type	Variation in content of mask waste			
		0%	1%	2%	3%
1	Penetration, (0,1 mm)	25°C 66.7	58.1	51.5	44.7
2	Kinematic Viscosity (cSt)	135°C 335	376	448	514
3	Softening Point, °C	48.5	49	52.5	55
4	Ductility at 25°C, (cm)	150	61	55	50.5
5	Flash point (°C)	328	334	338	340.5
6	Specific gravity	1.031	1.026	1.015	1.010
7	Weight Lost (%)	0.31	0.18	0.16	0.14

### 3.3. Discussion

#### A. Penetration Testing

The penetration test results show that the inclusion of mask fibers to 60/70 penetration asphalt decreases the penetration value, indicating that the asphalt is getting harder. Increasing the hardness of the asphalt will increase the resistance to grooves. The complete penetration test results can be seen in

Figure 1.

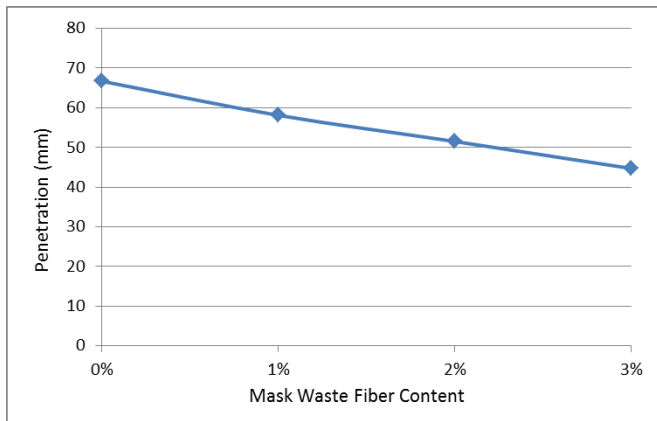


Figure 1. Relationship between waste mask fiber content and penetration

### B. Viscosity Testing

The viscosity test results showed that the inclusion of mask fibers to 60/70 penetration asphalt will increase its viscosity value, which indicates that the asphalt is getting thicker. The increasing viscosity value of asphalt will result in higher mixing temperature and compaction temperature. The complete viscosity test results can be seen in Figure 2.

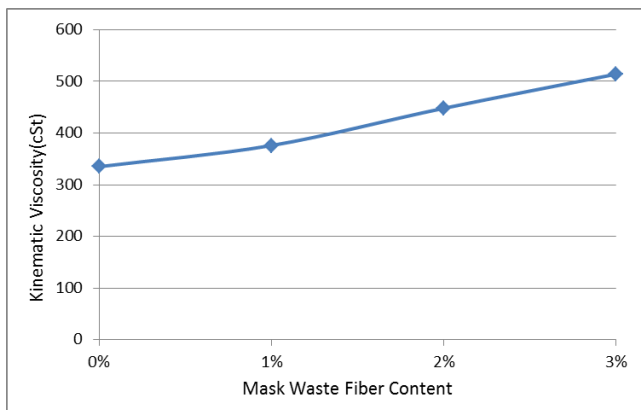


Figure 2. Relationship between waste mask fiber content and viscosity

### C. Softening Point Testing

The results of the softening point test showed that the inclusion of mask fibers to 60/70 penetration bitumen increases the mushy point value, indicating that the bitumen is less sensitive to high temperatures. The complete softening point test results can be seen in Figure 3.

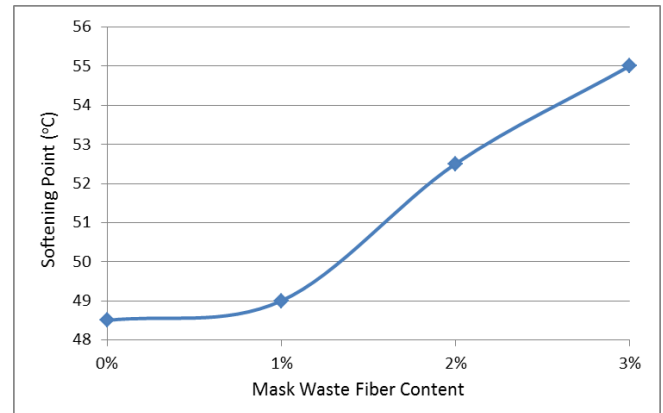


Figure 3. Relationship between waste mask fiber content and softening point

### D. Ductility Testing

The ductility test results show that the inclusion of mask fibers to 60/70 penetration asphalt decreases its ductility value, which indicates that the asphalt becomes stiffer and tends to lose its flexibility. This decrease will result in a decrease in the resistance of the asphalt to cracking. The complete ductility test results can be seen in Figure 4.

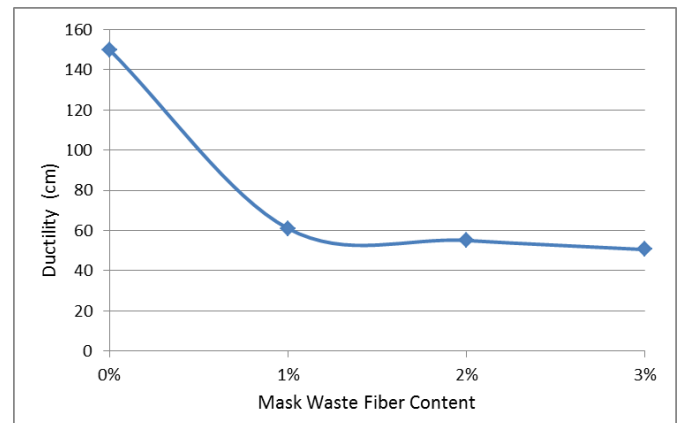


Figure 4. Relationship between waste mask fiber content and ductility

### E. Flash Point Testing

The flash point test results showed that the inclusion of mask fibers to 60/70 penetration asphalt will increase the flash point of asphalt. This indicates that the addition of fiber mask can increase the maximum heating temperature. The complete flash point test results can be seen in Figure 5.

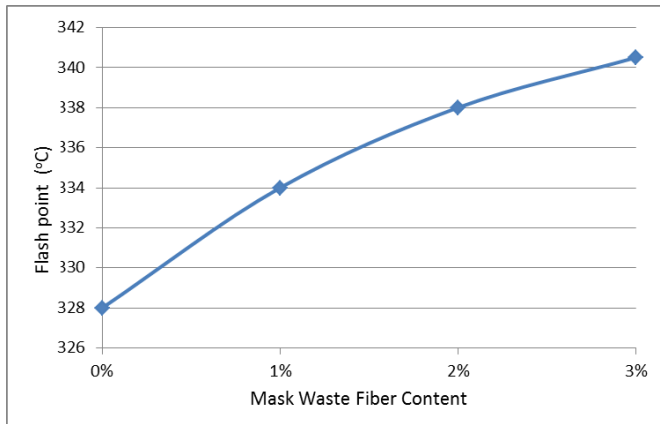


Figure 5. Relationship between mask waste fiber content and flash point

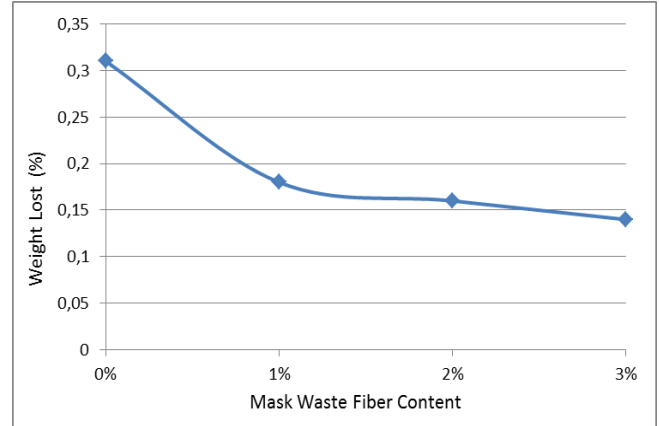


Figure 7. Relationship between waste mask fiber content and weight loss

#### F. Specific Gravity Testing

The specific gravity test results show that the inclusion of mask fibers to 60/70 penetration asphalt will decrease or shrink. This indicates that the addition of fiber masks can reduce the weight of asphalt. The complete asphalt specific gravity test results can be seen in Figure 6.

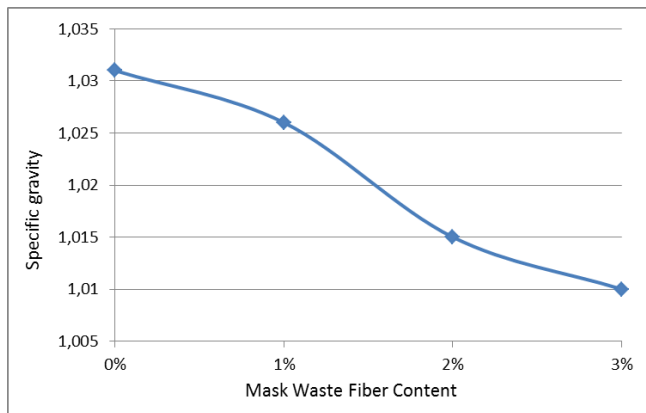


Figure 6. Relationship between waste mask fiber content and specific gravity

#### G. Weight Loss Testing

The results of the asphalt weight loss test showed that the inclusion of mask fibers to 60/70 penetration asphalt will tend to decrease. The level of fiber mask addition does not significantly affect the weight loss of asphalt so that the consistency of asphalt is still maintained. The complete asphalt weight loss test results can be seen in Figure 7.

## 4. Conclusion

Based on the collected data, analysis, and discussions conducted, the following conclusions have been drawn:

1. The addition of medical mask waste into 60/70 penetration asphalt will largely increase the hardness of asphalt.
2. In the review of the rheological characteristics of asphalt, the addition of asphalt will reduce the value of penetration, ductility, specific gravity, and weight loss, and increase the value of viscosity, softening point, and flash point.
3. The addition of mask waste to 60/70 penetration asphalt has both positive and negative impacts. On the positive side, the addition of mask waste results in increased asphalt hardness, enhancing resistance to rutting. Meanwhile, the negative impact is that the addition of mask waste will reduce the resistance to cracking because the elasticity level is reduced.

Drawing from the analysis and conclusions presented above, the following recommendations can be made:

1. In future research, mask waste is planned to be used as an additive in asphalt mixtures.
2. It is necessary to consider using many variations in the percentage of use of mask waste.

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