Surgical Mask: A New Solution for Flexible Pavement Distress

Rafi Shahriar Alam[1], Hameem Al Hussain[2]

[1]Department of Technology, Management and Economics, Transportation & Logistics, Technical University of Denmark

[2]Assistant Engineer, Water Resources Planning Organization (WARPO), Ministry of water resources, People's Republic of Bangladesh

***Corresponding Author**

DOI: https://doi.org/10.51584/IJRIAS.2025.1005000116

Received: 15 May 2025; Accepted: 19 May 2025; Published: 21 June 2025

ABSTRACT

The spread of the Coronavirus epidemic has led to a tremendous rise in plastic waste pollution around the world. In an effort to reduce plastic pollution, this study devised a unique method by employing surgical mask as an antistripping additive to hot mix asphalt to improve the mechanical and rheological qualities of 60/70 grade bitumen, by combining it with used surgical masks in four different proportions by weight of asphalt using wet process, following the ASTM specification. To ascertain the optimum content of mask and investigate the properties of PlastiPhalt mix, several tests have been conducted including Dynamic Shear Rheometer test, Asphalt Pavement Analyzer rutting test and Marshall test. The results of this study reveal that rutting depth decreased from 5.4 mm to 3.5 mm while mask content increased from 5% to 10%, and 10% mask content sample has a lower $G^*/\sin(\delta)$ value than that of 5%, indicating this as an ideal range for mask content to exhibit maximum resistance against fatigue and rutting distress. The Marshall test also supports this conclusion, stating that the optimum mask content is 8.27% of total asphalt (0.49% of total mixture) for optimum asphalt content of 5.95%. The result also illustrates that mask incorporation reduces sensitivity to temperature changes and improves stiffness of the bituminous mix, which results in an enhancement of resilience to rutting, fatigue, and aging. Therefore, using SFM in pavement mix is suggested, since it helps to strengthen the pavement mix as well as recycle plastic waste promoting environmental protection.

Keywords: Coronavirus epidemic; plastic pollution; surgical mask; wet process; recycle plastic waste.

INTRODUCTION

Globally, the COVID-19 epidemic has caused significant problems with health, finances, and the environment (Garel and Petit-Romec, 2020). The timeline and mechanisms by which this pandemic will conclude remain uncertain (Yong, 2021). Personal protective equipment (PPE) use has increased significantly as compared to the time before the current pandemic (Maderuelo-Sanz et al., 2021). This is partly because of the newly enacted PPE regulations, namely the obligation to wear surgical masks to stop the virus' spread (Rowan and Laffey, 2021). According to Ilyas et al. (2020), it is projected that the annual compound growth rate of the supply of surgical masks would be 20% from 2020 to 2025. The aforementioned pattern is expected to endure. The disposal of surgical masks poses a harm to the environment, despite the urgent necessity for their use (Boroujeni et al., 2021). Surgical masks are frequently disposed of in significant quantities on a global scale. Based on the findings of Prata et al. (2020), it has been estimated that a monthly production of 129 billion surgical masks occurred in 2020. According to Saberian et al. (2021), an alternative calculation indicates that the global utilization of surgical masks on a daily basis exceeded 6.68 billion units, equivalent to approximately 206,470 metric tons, as a consequence of the COVID-19 pandemic. The masks' lightweight nature renders them susceptible to displacement by wind and rain, regardless of their disposal method, including abandonment or deposition in landfills. This phenomenon elucidates the prevalence of discarded surgical masks in urban areas, public recreational spaces, and vehicular resting areas. Ultimately, the transportation of discarded surgical masks to rivers and oceans poses a significant threat to marine life

(Kilmartin-Lynch et al., 2021). According to a study conducted by Lee et al. (2021), the total number of masks that entered the world's waters in 2020 was expected to be around 1.56 billion. Moreover, as per sources, it is anticipated that in the foreseeable future, the quantity of surgical masks present in the water would surpass the population of jellyfish. The issue of microplastic pollution has been exacerbated by the disposal of used personal protective equipment (PPE), including surgical masks, into marine environments (Torresa and De-la-Torreb, 2021).

At present, the predominant techniques employed for recycling garbage masks encompass high-temperature incineration, landfill collection, mechanical recycling, and chemical recycling. High thermal energy is needed for high-temperature combustion. Additionally, it creates a number of toxic byproducts that will seriously pollute the environment. Microorganisms in the soil are used in the landfill collection method to break down the polymers. This procedure is time-consuming and also pollutes the soil secondarily. To combine waste masks with polymer or inorganic fillers, melt processing is used. Chemical processes like pyrolysis or gasification are used to break down large molecular polymers into smaller ones, which can then be reconstituted to create new materials. This complicated process uses a lot of energy. Due to this, using the current recycling and treatment methods for used surgical masks does not reduce environmental pollution or benefit the economy.

Again, the demand for roads is growing every year. The highway engineers are considering additional approaches to address this growing challenge. Adding polymers to improve the service properties of road paving applications was once considered, but it is now a viable alternative. To achieve improved service properties over a wide temperature range, a variety of additives are used. Numerous studies conducted in numerous nations have supported the advantages of adding polymers to bitumen (Hossain, 2006). The properties of bituminous mixture should be improved because poor performance will necessitate more maintenance, repairs, and in some cases, even pavement replacement, requiring more material and natural resource consumption. Adding waste materials to the binder as an additive can be a significant move in this perspective.

This study investigates the feasibility of converting surgical masks into an additive for hot mix asphalt (HMA) in order to improve the mechanical and rheological properties of asphalt pavement, hence providing a means of reducing PPE pollution. In this study, a number of experiments were carried out to examine the properties of HMA mixes employing various percentages of surgical masks for pavement applications. This study attempts to evaluate the improvements in asphalt modification brought about by the use of SFM against the rutting and fatigue distress and to decide whether adding SFM to the modified mixture is practical.

LITERATURE REVIEW

Hamedi et al. (2018) employed polypropylene, also known as PP, as an antistripping component in HMA. The findings of the tests indicated that increasing the proportion of polypropylene (PP) in asphalt mixtures boosted the mixtures' durability to both wet and dry conditions. However, there hasn't been a lot of research done on how the presence of PP in HMA affects rutting resistance. Kathari (2016) conducted research to determine how the presence of polypropylene (PP) fibers influenced the properties of asphalt binders. It was discovered that adding PP fibers to the material lessened its sensitivity to heat and improved its resistance to high-temperature permanent deformation. However, not a lot of study has been done to investigate how the presence of PP in HMA impacts the rutting resistance of the grass. Additionally, study conducted by Esfandabad et al. in 2020 found that utilizing polymers as asphalt binders can improve the engineering properties of flexible pavements. These attributes include Marshall stability, water resistance, and crack propagation resistance. Waste polythene was incorporated into the bituminous paving mix design by Sarma and Srikanth (2018). It was found that adding waste polyethene increases stability compared to using traditional bituminous mix. However, not a lot of study has been done to investigate how the presence of polythene in the asphalt mix impacts the material's rheological qualities. Different types of waste plastic materials were combined with High Density Poly Ethylene (HDPE) by Hinishoglu and Agar (2004) to modify binders at various blending temperatures, times, and HDPE percentages. According to the findings, the Marshall quotient percentage increased by 50% when compared to the control mixture. Researchers also found that the HDPE-modified bituminous mix had significantly greater resistance to severe deterioration and deformation.

According to a study by Zoorob and Suparma from 2000, adding LDPE waste plastic to bituminous mixtures can significantly improve their durability and stability (by about 2.5 times compared to control mixtures) while reducing their density. In addition, the findings of the investigation demonstrated that the PlastiPhalt fatigue life of the modified mixes was significantly greater than that of the control mixtures. Based on the outcomes of these tests, adding the polymer significantly improved the asphalt-modified mixture's resistance to rutting. In addition, polyethylene's use as a polymer for asphalt mixtures enhances the modified mixture's fatigue resistance, workability, and effectiveness. (Gibney, et. al., 2008). More recently, two studies on the reuse of single-use surgical masks for civil engineering applications have been carried out. These studies focused on the application of the masks to concrete (Kilmartin-Lynch et al., 2021) and the application of the masks to road base and subbase (Saberian et al., 2021). In the realm of civil engineering, the usage of surgical masks designed for single-time use could also be put to use in the asphalt application process.. The major purpose of this research is to determine whether single-use surgical masks can be successfully implemented in the field of civil engineering to improve the quality, performance, and attributes of asphalt.

MATERIALS & METHODOLOGY

In the following section, results from the survey will be presented in four different subsections.

Preparation of the surgical masks

In this study, the hot mix asphalt was modified using single use surgical masks. Surgical masks were made of polypropylene (PP). A series of tests were conducted to assess the physical and rheological characteristics of bitumen after it had been modified using surgical surgical masks. Ear-loops and metal nose strips of used surgical masks were taken off before incorporating it in bituminous mix. To study the behavior of the surgical masks in the HMA mixture, the masks were placed in an electronic oven at 145 °C for 10 minutes to melt them so that they could be combined with hot liquid bitumen.

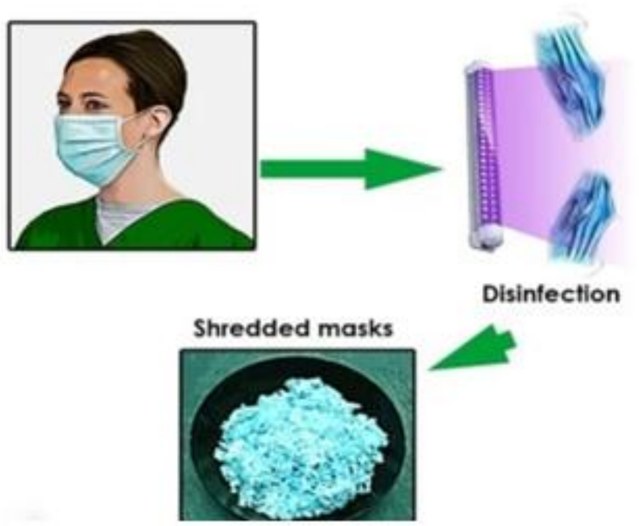

Figure 3.1: Shredded Surgical Mask (Castellote, M. et al., 2022)

Aggregate preparation and gradation

Table 3.1: Aggregate Gradation

Sieve Size (mm)	Mass retained, A (gm)	% retained, B	Cumulative % retained	Cumulative percent passing	ASTM composition of asphalt paving mixture
19mm	63	4.90	4.90	95.10	90 to 100
9.5mm	239	19.60	24.50	75.50	56 to 80

4.75mm	295	24.10	48.60	51.40	35 to 65
2.36mm	240	19.61	68.21	31.79	23 to 49
0.3mm	231	18.87	87.08	12.92	5 to 19
0.075mm	132	10.78	97.87	2.13	2 to 8
Pan	24				
Total=	**1224.00**				

The aggregates used in the experiment were oven dry at 105°C to remove moisture. According to Table 3.1, the aggregate gradation strictly follows the ASTM composition of the asphalt paving mixture.

Hot mix asphalt (HMA) composite materials and Mix Design

Asphalt 60/70 was utilized for the purpose of this research investigation. The amount of traffic and the temperature of the pavement each play a role in determining the Performance Grade (PG) of an asphalt binder. Modifications to the PG grade of asphalt binder are made according to the traffic circumstances and volume in order to achieve the goal of extending the design life of the paved area. For the purpose of this experiment, four different HMA combinations were chosen to contain different percentages of masks (5%, 10%, 20%, and 30% by weight of the asphalt, respectively). The combination was put together in accordance with the requirements of the ASTM asphalt paving mix specification. The aggregate employed in the mixture had a maximum size of 19 millimeters in terms of its size. In addition to this, coarse aggregate, fine aggregate, and stone dust were utilized (to make up the mineral filler). The Marshall Test, the APA Rut Test, and the Dynamic Shear Rheometer Test each included a total of 15 specimens that needed to be prepared. The specimens had corresponding dimensions of four inches for their diameter and two and a half inches for their thickness.

Figure 3.2: Mixture and mold sample

Laboratory Tests

In order to achieve the aim of this research, several tests have been conducted following the standard specifications as tabulated below:

Table 3.2: List of test and specification

Test Name	Standard Specification
Specific gravity Test	ASTM D70

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue V May 2025

Solubility Test	ASTM D2042
Loss on heating Test	ASTM D6
Penetration Test	ASTM D5
Ductility Test	ASTM D113
Softening point Test	ASTM D36
Flash and fire point test	ASTM D92
Marshall Test	ASTM D6927-06
Asphalt Paving Analyzer (APA) Rut Test	AASHTO TP 63
Dynamic Shear Rheometer (DSR) Test	AASHTO T 315-20

A flow chart of the research has been given below:

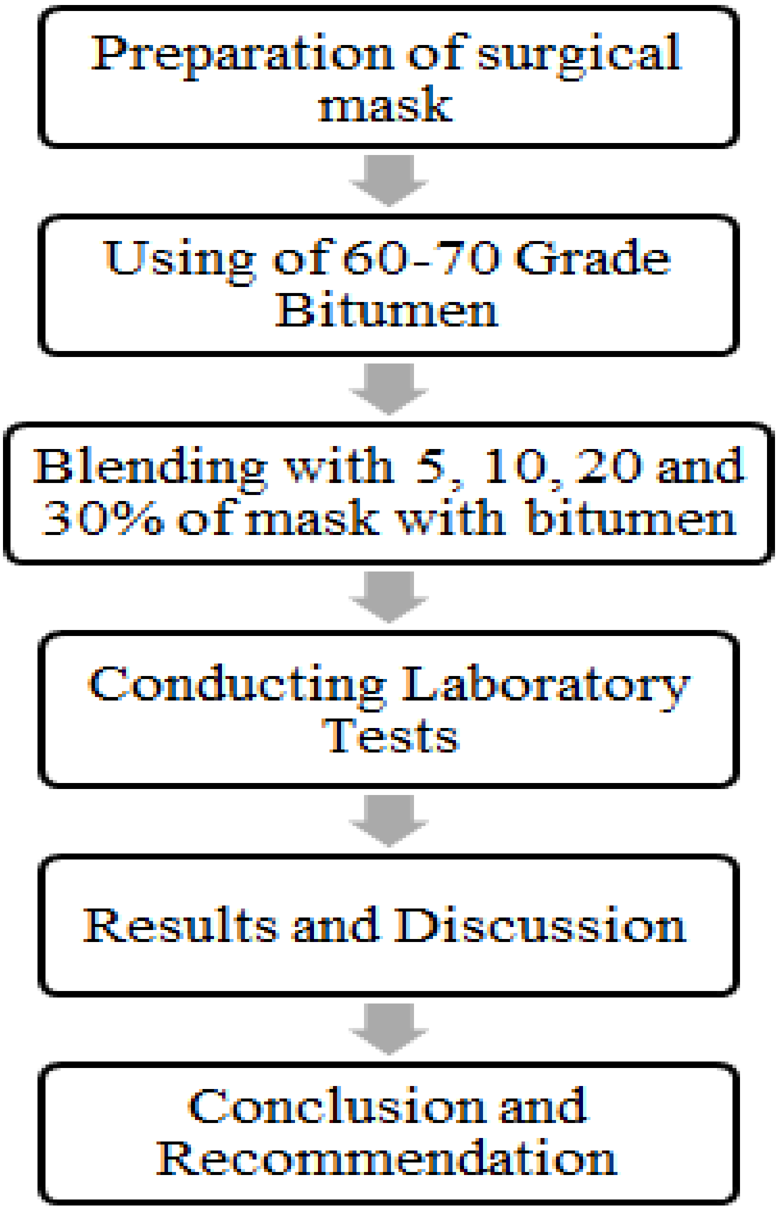

Figure 3.2: Flow chart of the research

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue V May 2025

RESULT & DISCUSSION

Table 4.1: List of test result and specification

	Bitumen + 0% Mask	Bitumen +5% Mask	Bitumen+10 % Mask	Bitumen+ 20% Mask	Bitumen+30% Mask	Standard Value for bitumen
Specific Gravity	1.020	1.013	1.009	1.005	1.001	1.01/1.06
% Soluble	99.7	99.1	98.2	97.8	96.5	Min 99%
Loss on heating (%)	0.06	0.04	0.03	0.02	0.01	Max 0.2%
Penetration Value (1/10) mm	66.70	44.02	25.04	17.06	9.04	60/70
Ductility Value (cm)	94.46	77.06	59.56	34.56	19.34	Min 100cm
Softening point value(°C)	50.00	61.45	71.56	80.90	89.98	49/56
Flash Point(°C)	290	305	335	295	210	Min 232
Fire Point(°C)	330	345	370	340	290	> flash point

Specific gravity test

As demonstrated in Table 4.1 the specific gravity of modified bitumen drops as the mask concentration in bitumen increases. For 30% addition of mask content, specific gravity has dropped significantly from 1.020 to 1.001. This happened because the specific gravity of surgical masks is less than that of bitumen.

Solubility test

The percent soluble of modified bitumen drops as the mask content in the bituminous mix increases. For 30% addition of mask content, the solubility percent has dropped from 99.7% to 96.5%.

Loss on heating test

The above table shows how volatile compounds are lost during the test as a result of heating with the addition of the mask. The test findings demonstrate that after including masks in bitumen, the volatile material loss during heating has decreased. Material loss for virgin bitumen is 0.06%, whereas, for bitumen treated with a 30% mask, it is found to be 0.01%.

Penetration test

Table 4.1 also demonstrates how the composition of a mask affects the penetration value. As the amount of masks increases from 0% to 30%, the penetration number gradually declines from 66.70 to 9.04, making the bituminous mix more rigid and reducing the susceptibility of the binder to increase its resistance to distress such as rutting and fatigue.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue V May 2025

Ductility test

The findings show that as the amount of masks in a binder increases, ductility drastically declines. As the amount of masks increases from 0% to 30%, the ductility value reduces from 94.46 cm to 19.34 cm, suggesting that the ductility property of pure bitumen is significantly impacted by the use of masks as a modifier. Although the aggregate content remain same but increase in mask allow the modified binder to fill voids and switch the physical properties.

Softening point test

As demonstrated in Table 4.1, the softening point increases to 89.98°C from 50°C in the case of a 30% addition of mask content. In order to soften the modified binder, a greater temperature will be needed as the polymer content of the binder increases its consistency. It shows that the inclusion of mask content greatly reduces the binder's sensitivity to temperature. This enhancement of the binder's properties will lessen the problem of pavement bleeding and segregation during the hot season, which is one of the major causes of pavement distress in tropical areas.

Flash & fire point test

The above table also summarizes the changes in flash and fire points. The results indicate that both the flash and ignition points rise with increasing mask concentration up to a maximum of 10%. The greater flash and fire point values brought on by the mask addition are encouraging in terms of safety concerns.

Marshall Test

Bitumen

Table 4.8.1: Marshall test parameters of bitumen

Sl. No.	% of bitumen content	Unit weight (lb/ft3)	VMA (%)	Va (%)	VFA (%)	Corrected Marshall stability (kN)	Flow (mm)	Marshall Quotient (kN/mm)
1	5.0	144.764	17.86	7.08	60.38	16.53	3.29	5.03
2	5.5	146.277	18.25	5.46	70.08	17.61	3.42	5.14
3	6.0	147.596	18.64	3.97	78.73	18.20	3.50	5.20
4	6.5	147.218	19.02	3.57	81.20	17.20	3.69	4.67
5	7.0	144.627	19.40	4.65	76.02	16.76	3.73	4.50

Table 4.8.2: Marshall test parameters at Op1timum Bitumen Content

Sl. No.	% of bitumen content	Unit weight (lb/ft3)	VMA (%)	Va (%)	VFA (%)	Corrected Marshall stability (kN)	Flow (mm)	Marshall Quotient (kN/mm)
1	5.95	147.500	18.60	4.10	78.00	17.94	3.56	5.08

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue V May 2025

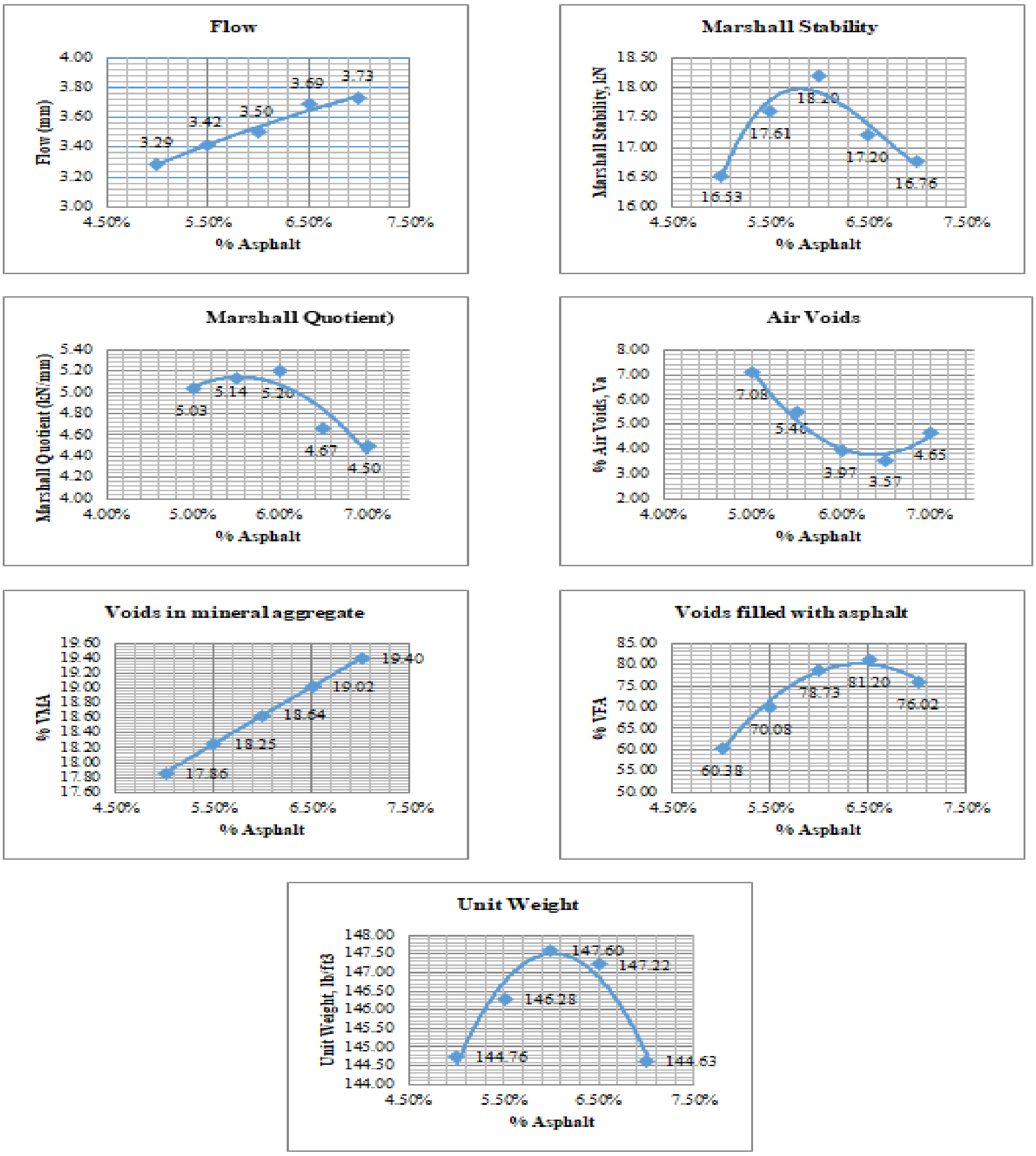

Figure 4.8.1: Graphs for Marshall mix design of bitumen

Marshall tests were primarily used to ascertain and assess how well asphalt mixtures could withstand collapsing and long-lasting deformation, particularly rutting deformation. Figure 4.8.1 illustrates the findings of the Marshall test as the asphalt content varies from 5% to 7% of the total mix, including the Marshall stability, flow, Marshall quotient, unit weight, air voids, voids in mineral aggregate, and voids filled with asphalt. By averaging the bitumen content at maximum unit weight, maximum stability and 4% air voids, optimum bitumen content of 5.95% has been determined. Marshall parameters regarding 5.95% have been tabulated in Table 4.8.2.

Bitumen + Mask

Table 4.8.3: Marshall test parameters of bitumen

Sl. No.	% of mask content	Unit weight (lb/ft3)	VMA (%)	Va (%)	VFA (%)	Corrected Marshall stability (kN)	Flow (mm)	Marshall Quotient (kN/mm)
1	5.0	142.322	26.88	7.06	81.09	20.78	2.25	9.24

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue V May 2025

2	10.0	143.268	26.39	2.58	91.42	23.17	2.44	9.51
3	20.0	124.380	32.24	4.31	63.38	19.75	2.77	7.14
4	30.0	110.709	37.22	5.19	49.05	18.60	2.95	6.31

Table 4.8.4: Marshall test parameters at Optimum Mask Content

Sl. No.	% of mask content	Unit weight (lb/ ft3)	VMA (%)	Va (%)	VFA (%)	Corrected marshall stability (kN)	Flow (mm)	Marshall Quotient (kN/ mm)
1	8.27	132.000	32.50	4.80	85.00	21.70	2.39	9.6

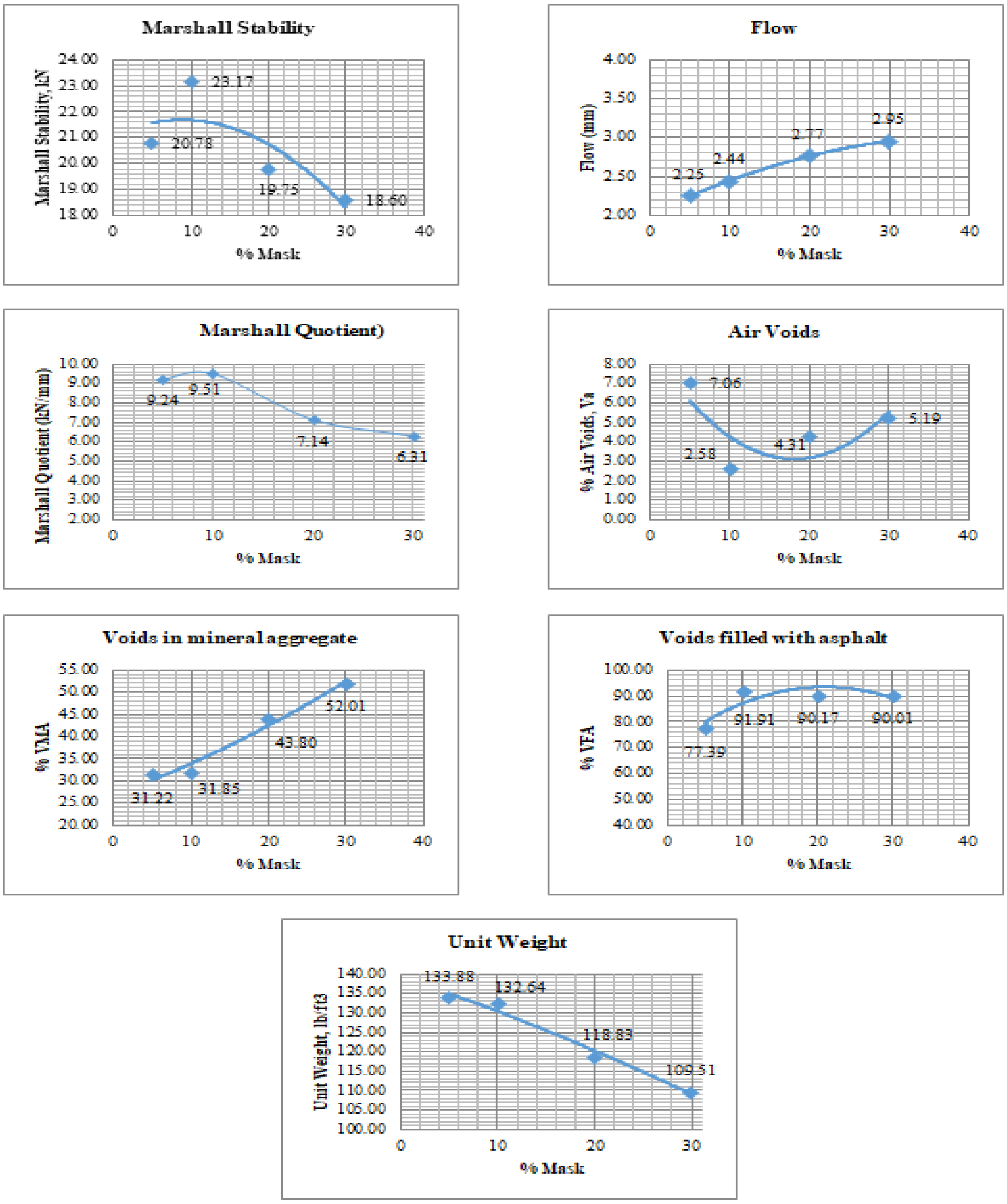

Figure 4.8.2: Graphs for Marshall mix design of PlastiPhalt

Table 4.8.3 and Figure 4.8.2 illustrates the findings of the Marshall test as the mask content varies from 5% to 30% with 5.95% of the bituminous mix. A graphical presentation of Marshall stability, flow, Marshall quotient, unit weight, air voids, voids in mineral aggregate, and voids filled with asphalt has been shown. By averaging the mask content at maximum unit weight, maximum stability, and 4% air voids, optimum mask content of 8.27% has been determined. Table 4.8.2 tabulates the Marshall parameters regarding 8.27% mask content. From the study of the behavior of mask-modified bitumen, it can conclude that the antistripping additive increases the stability by 20.96% as well as reduce the flow by 48.95%, making the plastiphalt mix resist the deformations to a greater extent under heavy wheel loads.

Asphalt Paving Analyzer (APA) Rut Test

Table 4.9.1: Overview on the effect of rut depth

Test No.	**Materials**	**Rut Depth (mm)**
1	Bitumen+ 0% Mask	7.1
2	Bitumen+5% Mask	5.4
3	Bitumen+10% Mask	3.5
4	Bitumen+20% Mask	4.5
5	Bitumen+30% Mask	5.1

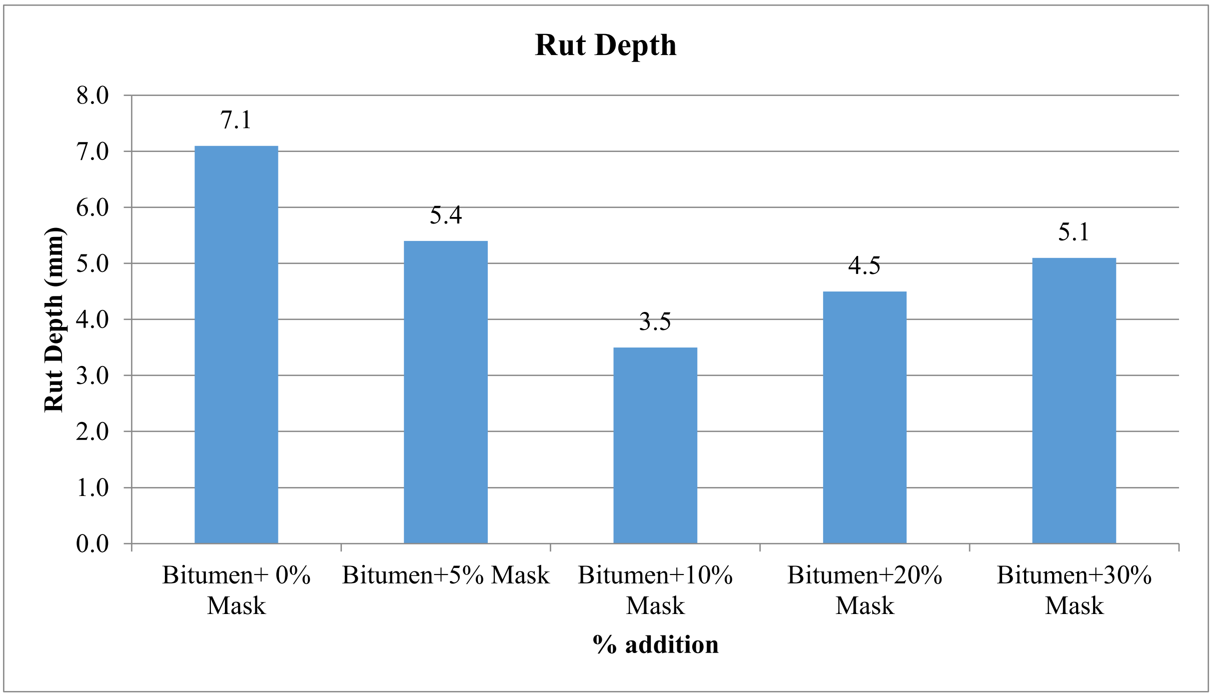

Figure 4.9.1: Overview on the effect of rut depth

Table 4.9.2: Overview on the effect of rut depth

Strokes Count	Bitumen+ 0% Mask	Bitumen+5% Mask	Bitumen+10% Mask	Bitumen+20% Mask	Bitumen+30% Mask
	Rut Depth (mm)	**Rut Depth (mm)**	**Rut Depth (mm)**	**Rut Depth (mm)**	**Rut Depth (mm)**
0	0.0	0.0	0.0	0.0	0.0

25	2.5	1.1	0.6	0.9	1.0
4000	5.1	3.9	2.3	2.8	3.1
8000	7.1	5.4	3.5	4.5	5.1

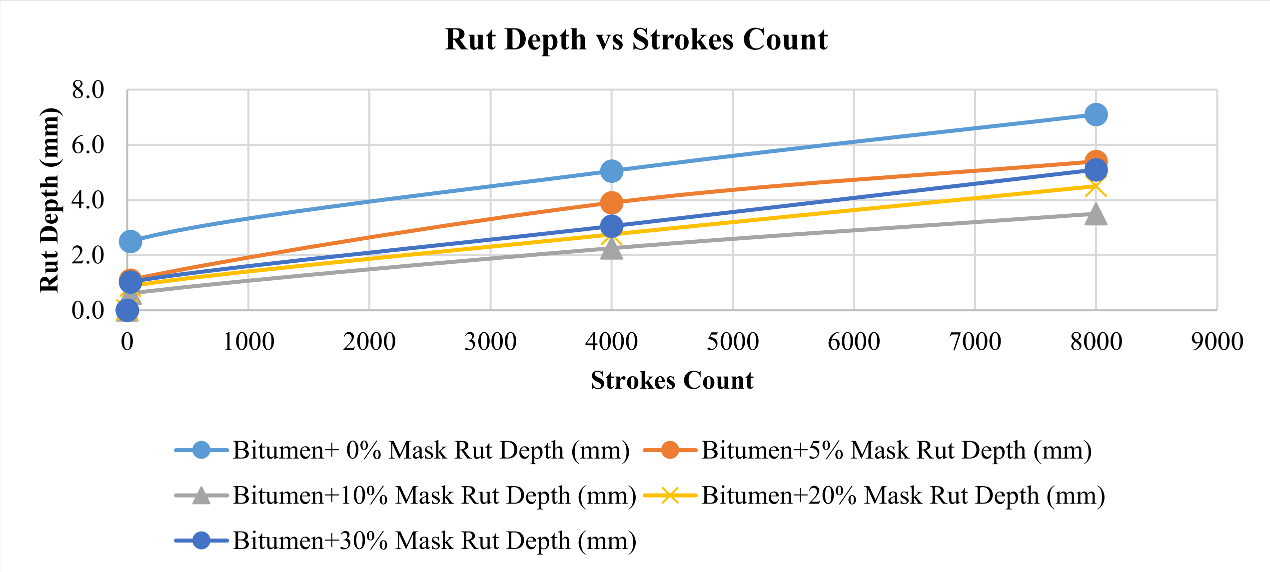

Figure 4.9.2: Overview on the effect of rut depth

Fig. 4.9.1 and 4.9.2 shows the comparison between the virgin bitumen mix and different percentages of mask mix specimens. As seen from the figure, the adoption of surgical masks has improved the rutting resistance of hot mix asphalt. The rutting depth of the control sample was observed at 7.1 mm; however, by increasing the mask content from 5% to 10%, the rutting depth reduced from 5.4 mm to 3.5 mm at 8000 strokes, which is lower than the control mix and lower than the maximum specification requirements for local traffic pavement and interstate highway pavement. It should be mentioned that the maximum rut depth is 4.5 mm (≥ 30 million ESALs) for interstate highway pavement in the US, and for local traffic pavement, it is 11.5 mm (≤ 0.3 ESALs). Rut depth portrays an increase in value, as the mask content exceeds 10% indicating that the optimum mask content ranges between 5% to 10%. Therefore, it can be concluded that the melted mask functioned like an asphalt binder to bind the aggregates with adhesion properties and reduce the rut depth. Between 5% to 10% of mask content4.10 Dynamic Shear Rheometer (DSR) Test

Table 5.0: Overview on the effect of G*/sin (δ)

Temperature (°C)	Bitumen+ 0% Mask	Bitumen+5% Mask	Bitumen+10% Mask	Bitumen+20% Mask	Bitumen+30% Mask
	G*/sin (δ), kPa	**G*/sin (δ), kPa**	**G*/sin (δ), kPa**	**G*/sin (δ), kPa**	**G*/sin (δ), kPa**
46.00	30.1	78.8	75.6	71.7	65.7
52.00	10.2	53.5	51.1	47.6	44.2
58.00	5.1	31.5	27.5	21.5	19.5
64.00	3.2	22.5	18.5	13.5	9.5
70.00	1.5	13.5	10.2	8.1	5.1

76.00	0.5	8.5	5.5	3.5	1.7
82.00			3.5	2.7	1.5
88.00				1.2	0.7
94.00					0.3

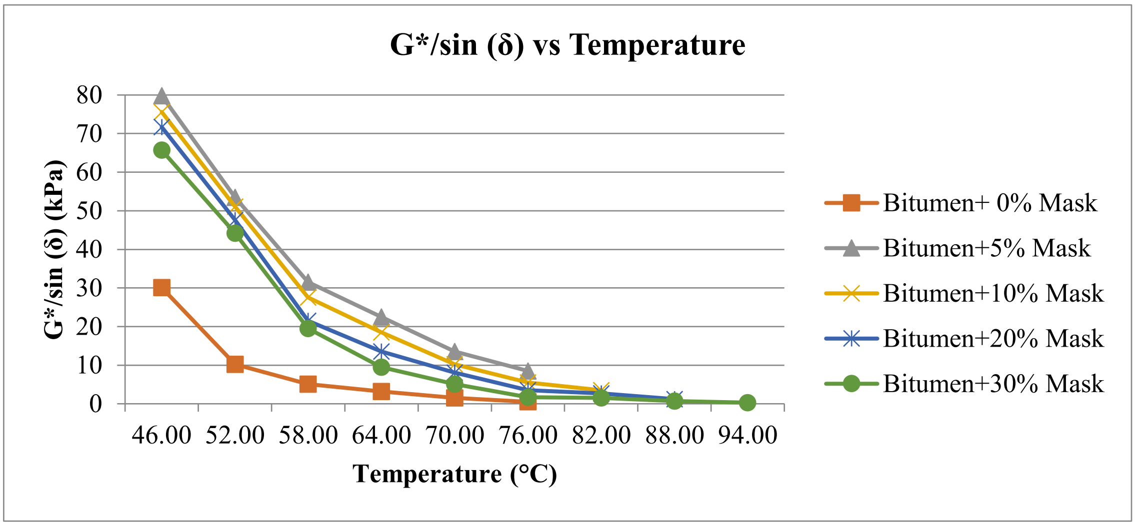

Figure 5.0: Overview on the effect of G*/sin (δ)

Table 5.0 and Figure 5.0 shows the G*/sin (δ) trend for virgin and modified bitumen 60/70 in a temperature ranging from 46ºC to 94ºC and at the constant frequency of 1.59 Hz. Data illustrates that as the percentage of mask raises, G*/sin (δ) increases as well. At 30% of mask addition, the G*/sin (δ) still met the condition even though the temperature reached 94ºC. This shows that mask usage will improve the performance of binder against permanent deformation (rutting) at high temperature. However, G*/sin (δ) of 10% is lower than that of 5%, indicating that 5% to 10% of the mask content is the optimum range.

Based on the overall assessment it can be stated that the optimum mask content is 8.27% of total asphalt for optimum asphalt of 5.95%. Therefore, this means that the optimum mask content of the whole percentage mixture is (8.27% x 5.95) % = 0.49%.

CONCLUSION AND RECOMMENDATION

The pandemic caused by COVID-19 has had a detrimental effect on the ecosystem on a global scale. One of the most significant challenges facing the planet today is the fact that billions of polypropylene, one-time-use surgical masks are used every day all around the world. The purpose of this pilot study was to investigate the effects of using surgical masks in hot mix asphalt. Through a series of lab tests, the potential use of surgical masks that have been shred in asphalt and the effectiveness of modified mixes were demonstrated.

According to the findings, the rutting depth values decreased from 5.4 mm to 3.5 mm as the mask content increased from 5% to 10%. Additionally, the sample with the 10% mask content had a lower G*/sin (δ) value than the sample with the 5% mask content, indicating that this range is the ideal range for mask content. These claims are also supported by the Marshall test, which states that the ideal mask content is 8.27% of the asphalt content. This not only raises the stiffness of the mixes and strengthens the adherence of the aggregates, but it also provides the pavement with greater resistance when it is subjected to traffic pressure and improves the pavement so that it has a lessening effect on the effect of distress. The rutting effect can also be lessened by the modified bitumen. By recycling used surgical masks in HMA, this study suggested a novel method for reducing the waste produced by the pandemic. This will not only help the environment but will also add financial value.

In light of all the experiments that were carried out, this conclusion can be drawn that the inclusion of the mask improves the various properties of a conventional bituminous road. The results of this study demonstrate that the mixtures with various surgical mask percentages had strong resistance to distress, such as rutting, fatigue, and aging. Taking all of these considerations into account, this can be confidently inferred that the addition of polymer can help to create a mix that is more stable and long-lasting for the pavements. This small study not only makes good use of the non-biodegradable waste mask but also offers a better pavement with increased strength and lifespan. As a result of this study, the quantity of masks that will need to be disposed of through methods such as incineration and landfilling will be reduced, which will be beneficial to the environment. It will not only add value to the used masks but also create environmentally friendly technology.

ACKNOWLEDGEMENTS

Rafi Shahriar Alam: Conceptualization, Literature Review, Methodology, Experiment, Data curation, Writing, editing, Supervision. **Hameem Al Hussain:** Literature Review, Methodology, Experiment, Data curation, Writing, and editing.

Funding

No specific grant was given to this research by funding organizations in the public, private, or nonprofit sectors.

Conflict of Interest

The authors declare no conflict of interest in preparing the article.

Data Availability

The authors confirm that the data supporting the findings of this study are available within the article.

REFERENCES

1. Boroujeni, M., Saberian, M. & Li, J., 2021. Environmental impacts of COVID-19 on Victoria, Australia, witnessed two waves of Coronavirus. Environ. Sci. Pollut. Res. Int., 28(11)(14182-14191).
2. AASHTO, 2009. AASHTO TP 63 Standard Method of Test for Determining Rutting Susceptibility of Hot Mix Asphalt (HMA) Using the Asphalt Pavement Analyzer (APA). American Association of Highway and Transportation Officials (AASHTO).
3. AASHTO, 2020. AASHTO T 315-20 Standard Method of Test for Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR). American Association of Highway and Transportation Officials (AASHTO).
4. Ahmed, L. A., 2006. Improvement of Marshall Properties of the Asphalt Concrete. Eng. & Technology, Volume 25, p. 383–394.
5. Alexandre, G. & Arthur, P.-R., 2021. Investor rewards to environmental responsibility: Evidence from the COVID-19 crisis. Journal of Corporate Finance, 68(C)(101948).
6. ASTM, 2010. ASTM D36-06 Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus). American Society for Testing and Materials (ASTM).
7. ASTM, 2015. ASTM D6927-06 - Standard Test Method for Marshall Stability and Flow of Bituminous Mixtures. American Society for Testing and Materials (ASTM).
8. ASTM, 2018. ASTM D113 Standard Test Method for Ductility of Asphalt Materials. American Society for Testing and Materials (ASTM).
9. ASTM, 2018. ASTM D92 Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester. American Society for Testing and Materials (ASTM).
10. ASTM, 2018. ASTM-D6 Standard Test Method for Loss on Heating of Oil and Asphaltic Compounds. American Society for Testing and Materials (ASTM).
11. ASTM, 2020. ASTM D5/D5M-20 Standard Test Method for Penetration of Bituminous Materials. American Society for Testing and Materials (ASTM).

12. ASTM, 2021. ASTM D70 Standard Test Method for Density of Semi Solid Bituminous Materials (Pycnometer Method).
13. ASTM, 2022. ASTM D2042 Standard Test Method for Solubility of Asphalt Materials in Trichloroethylene or Toluene. American Society for Testing and Materials (ASTM).
14. Casey, D., McNally, C., Gibney, A. & Gilchrist , M. D., 2008. Development of a recycled polymer modified binder for use in stone mastic asphalt. Resources, Conservation & Recycling, Volume 52(10), pp. 1167-1174.
15. Esfandabad, A. S., Motevalizadeh, . S. . M. & Asgharzadeh, S. M., 2020. Fracture and mechanical properties of asphalt mixtures containing granular polyethylene terephthalate (PET). Construction and Building Materials, 259(120410).
16. Haider, S., Hafeez, I., Jamal & Ullah, R., 2020. Sustainable use of waste plastic modifiers to strengthen the adhesion properties of asphalt mixtures. Construction and Building Materials, Volume 235, pp. 1-15.
17. Hamedi, G. H., Azarhoosh, . A. & Khodadadi, M., 2018. Effects of Asphalt Binder Modifying with Polypropylene on Moisture Susceptibility of Asphalt Mixtures with Thermodynamically Concepts. Periodica Polytechnica Civil Engineering, 62(4)(901–910).
18. Hınıslıoğlu, S. & Ağarb, E., 2004. Use of waste high density polyethylene as bitumen modifier in asphalt concrete mix. Materials Letters, 58(3–4), pp. 267-271.
19. Hossain, M. A. A., 2012. Study on the rheological properties of polymer modified bituminous binder and mixes.
20. Ilyas, S., Srivastava, R. R. & Kima, H., 2020. Disinfection technology and strategies for COVID-19 hospital and bio-medical waste management. Sci. Total Environ., 749(141652).
21. Kathari, P. M., 2016. Rheological Properties of Polypropylene Reinforced Asphalt Binder. Transportation Infrastructure Geotechnology, 3(109-126).
22. Kilmartin-Lynch, S. et al., 2022. Application of COVID-19 single-use shredded nitrile gloves in structural concrete: Case study from Australia. Sci. Total Environ., 812(151423).
23. Kilmartin-Lynch, S. et al., 2021. Preliminary evaluation of the feasibility of using polypropylene fibres from COVID-19 single-use face masks to improve the mechanical properties of concrete. J. Clean Prod., 296(126460).
24. Lee, S. B. et al., 2021. Production of value-added aromatics from wasted COVID-19 mask via catalytic pyrolysis. Environ. Pollut., 283(117060).
25. Maderuelo-Sanz , R. et al., 2021. The recycling of surgical face masks as sound porous absorbers: Preliminary evaluation. Sci. Total Environ., 786(147461).
26. Needhidasan, S. & Agarwal, S., 2020. A review on properties evaluation of bituminous addition with E-waste plastic powder. Materials Today: Proceedings, 22(3)(1218-1222).
27. Prata, J. C. et al., 2020. COVID-19 Pandemic Repercussions on the Use and Management of Plastics. Environ. Sci. Technol., 54(13)(7760-7765).
28. Rowan, N. J. & Laffey, J. G., 2021. Unlocking the surge in demand for personal and protective equipment (PPE) and improvised face coverings arising from coronavirus disease (COVID-19) pandemic - Implications for efficacy, re-use and sustainable waste management. Sci. Total Environ., 752(142259).
29. Saberian, M., Li, J., Kilmartin-Lynch, . S. & Boroujeni, . M., 2021. Repurposing of COVID-19 single-use face masks for pavements base/subbase. Sci. Total Environ., 769(145527).
30. Sarma, M. S. & Srikanth, B., 2018. Study on use of Waste Polythene in Bituminious. International Journal for Modern Trends in Science and Technology, 04(06, June 2018).
31. Torres, F. G. & De-la-Torre, G. E., 2021. Face mask waste generation and management during the COVID-19 pandemic: An overview and the Peruvian case. Sci. Total Environ., 786(147628).
32. Yong, E., 2021. HOW THE PANDEMIC NOW ENDS. [Online].
33. Zoorob, S. & Suparma, L. B., 2000. Laboratory design and investigation of the properties of continuously graded Asphaltic concrete containing recycled plastics aggregate replacement (Plastiphalt). Cement & Concrete Composites, Volume 22, p. 233–242.