International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

A review of properties of bituminous mix containing bitumen modified with cigarette buds, steel slag, and granite powder

Anshul Kulkarni[1], Tarun Kumar Narnaure[2]

[1]M.E Student, Department of transportation engineering, Shri. G.S. Institute of Science and Technology, Indore (M.P)

[2]Assistant Professor, Department of CE & AMD, Shri. G.S. Institute of Science and Technology, Indore (M.P)

Abstract

Researchers have been focusing on a potential and stable solution for the top-notch environmental issue of pollution by imperishable waste products such as Cigarette Buds (CB), Steel Slag (SS) and Granite Powder (GP). The recycling of cigarette buds is not possible due to throwing away in the random manner. Cigarette buds are harmful for the environment because it consists of cellulose acetate fibers, burnt tobacco and tar in addition to multiple toxic chemicals. Depending upon the geographic and environmental conditions, it takes a large amount of time to biodegrade this waste which eventually contaminate the environment if left unattended. Therefore, CB could be utilized as a potential replacement of bitumen. On the other hand, natural resources such as aggregates and fillers form the important constituents of bituminous mix. Due to the significant industrial development, waste deposits (SS and GP) have increased in recent years. SS is metallurgical and waste material of steel industry & GP is a waste material of granite polishing industry, when used as a partial replacement of natural aggregate and lime respectively gives satisfactory results. Therefore, partial replacement of these elements with SS and GP respectively, would be a great solution towards the reduction of environmental impacts of road construction. In this study, a detailed review of different properties of modified bitumen and resulting mix containing CB, SS and GP has been presented. The properties of bituminous mix considered for review are density, penetration, softening point, viscosity, Marshall test parameters, rutting, indirect tensile strength, and modulus of rupture.

Keywords: Bitumen, cigarette buds, steel slag, granite powder, flexible pavement, modified binder, Marshall Stability test.

1. Introduction

These days, smoking tobacco in the shape of cigarette buds is a worldwide phenomenon. The cigarette b ud waste is transported away by the drains and ends up in the rivers, oceans, and beaches. This has disast rous effects on the environment because a single cigarette bud can pollute 500 litres of water [1] and cou ld endanger aquatic life. Around 40% of the waste retrieved in cities is made up of cigarette waste, and u tilizing it in compost pits worsens the circumstances further [2].

One of the top priorities for people worldwide is environmental conservation. The tremendous amount of waste produced around the world has been the subject of extensive research for a long time. A different perspective on using waste materials such as cigarette buds, steel slag, and granite powder for building different structures in a way that keeps the quality intact and lessens the burden on already-depleting natural resources is presented in this study, which builds on earlier research on the topic of leveraging waste. The reduction in effort and potential cost savings over new materials is the main benefit of employing these materials.

1.1. Cigarette Butts (CBs)

The term "filter" refers to the lower portion of the cigarette. Cigarette buds are comprised of cellulose acetate, a synthetic fibre. After researching the prevalence of smoking worldwide, Max Roser and Hannah Ritchie noted that there had been a significant rise in smokers worldwide. By 2012, it had already surpassed 1 billion. Even after various health awareness programmes, the World Health Organization estimated that there were 1.1 billion smokers worldwide in 2018. 2018; World Health Organization. Despite the statistics, there are undoubtedly a lot more smokers than there were in the past, and that number is certain to rise. In an effort to meet the rising demand, cigarette production has expanded. According to a recent study, there are currently 6 trillion cigarettes produced year, of which 5.8 trillion are consumed. By 2025, production will be 9 trillion, predicts the World Health Organization. The ecology is being severely impacted by these smoked cigarettes. Cigarette Butt Pollution Project, 2019. According to "The Terramar project," every minute, 2.3 million cigarette butts are dumped into the environment, and one out of every ten of these CBs ends up in a body of water. According to 'Truthinnitiave's research, 38% of all scattered waste is made up of cigarette butts. According to reports, even in public locations, almost 75% of smokers discard their cigarettes to the ground[1],[2].

Figure 1 shows the forecast for Cigarette sales in India.

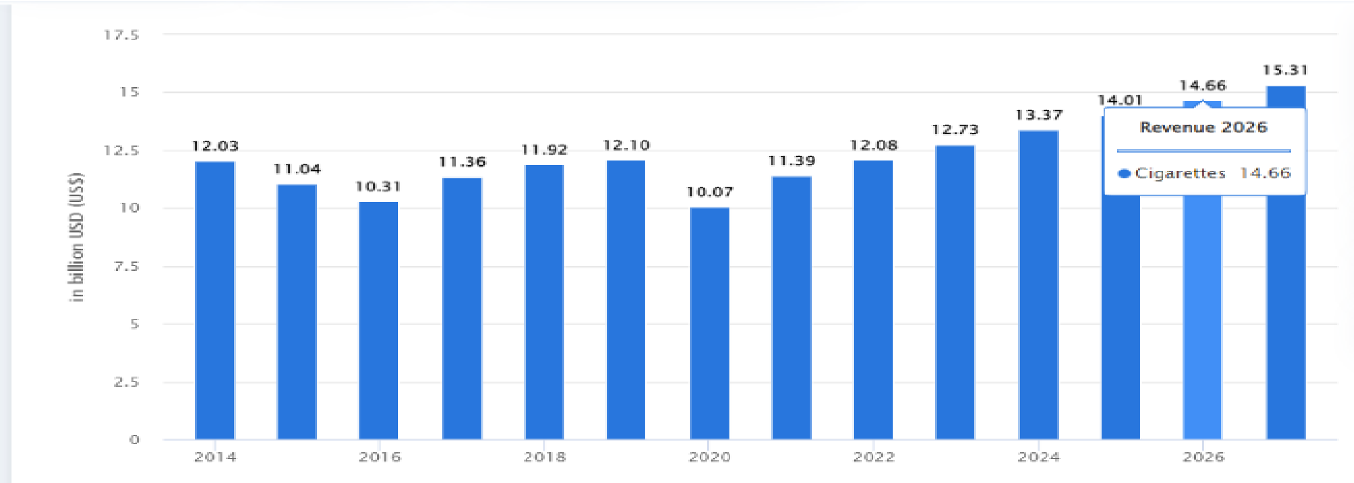

Figure 1: Image shows the forecast for Cigarette sales in India.

Figure 2 Cigarette butts (a) before to oven drying and (b) after the removal of extra tobacco and debris. (c) Grounded CBs used to prepare samples.

Figure 2: Cigarette butts (a) before to oven drying and (b) after the removal of extra tobacco and debris. (c) Grounded CBs used to prepare samples.

1.2 Steel Slag (SS)

When molten steel is removed from impurities in steel-making furnaces, it is produced as a by-product. As a molten liquid melt, the slag is a complex mixture of silicates and oxides that solidifies after cooling.

There are numerous grades of steel that can be produced, and each grade can have drastically different steel slag characteristics. Depending on the amount of carbon in the steel, grades can be divided into high, medium, and low categories. High-grade steels contain a lot of carbon. Greater oxygen levels are needed during the steel-making process in order to lower the quantity of carbon in the steel. In order to remove impurities from the steel and promote slag formation, it is also necessary to add more lime and do lime (flux).

According to the proposed National Steel Policy, 2017, crude steel production in India is expected to increase from the current level of 100 million tonnes per year to 300 million tonnes per year. As a result, the slag management system needs to be further strengthened in order to make successful and financially viable efforts to achieve its full utilisation (Recent trends in slag management & utilisation in the steel industry). Figure 4 depicts the various sizes of steel slag and Table 1 lists the chemical composition of steel slag [3].

Table 1- Chemical composition of Steel Slag Materials Mass(%) [4]

Material	Mass (%)
Fe	15-18
Sio2	9-12
Al2O3	1.4-0.6
CaO	51-58
MgO	1-3

Fe2O3	10-13
MnO	4-5
S	0.13-0.1
P2O5	3.2-2.1
Na2O	0.03-0.01
K2O	0.04-0.01

Figure 3: Image shows the different size of steel slag

1.3 Granite Powder (GP)

It is a powdered kind of industrial waste produced by the granite milling and polishing industries. Due to their airborne nature and ease of inhalation, these by-products are largely left unused and pose a risk to human health. Granite is often an acidic aggregate; its surface has a great texture depth, additional texture, and good wear resistance due to its microstructure. In addition, granite possesses a number of physical qualities that are superior to those of basalt and limestone, two other materials that are being utilised extensively in road paving, such as resistance to polishing.

All of these characteristics can ensure the depth of the texture and skid resistance of the road surface, which ideal coarse aggregates should have. However, the bonding or adhesion between granite and asphalt is insufficient to significantly increase the moisture stability of the asphalt-aggregate mixtures used in pavements. The use of granite for engineering purpose can be limited as a result. The interaction of granite and asphalt is a significant factor in the formation of the structure of asphalt mixtures. It has a direct impact on the fundamental pavement performance characteristics such strength, temperature stability, and mixture strength in the presence of water. Understanding the mechanisms dictating how granite and asphalt interact is essential for improving the performance of the mixture [5]. Granite powder's chemical makeup is displayed in Table 2.

Table- 2 Chemical Composition of Granite powder (%) [6]

Component	Percentage%
Silica	70-77
Alumina	11-14
Potassium oxide	03-05
Soda	03-05
Lime	1
Iron (Fe2O3)	02-03
Magnesia & Titania	Less than 1

2. LITERATURE REVIEW

Md Tareq Rahman et al (2020) stone mastic asphalt may employ modified bitumen with cigarette butt fibre. The bitumen in stone mastic asphalt is CB fibre modified demonstrated better binder drain off resistance in the investigation on binder drain off resistance. A precise rheological analysis of the modified bitumen and the outcomes of the Marshall stability and flow tests were used to determine the compatibility of the CB fibre modified PMB A10E in stone mastic asphalt.. The scope of future research in this field has been expanded as a result of this paper's findings. To determine the appropriateness of CB fibre modified binder in the larger asphalt pavement business, this study model can be used to a different kind of asphalt concrete utilising different kinds of bitumen. Stone mastic asphalt (SMA) samples were created using PMB A10E that had been changed with 0% fibre, 0.3% cellulose fibre, 0.2% and 0.3% CB fibre, and 0% fibre. The CB modified bitumen prepared by SMA produced findings with a very low coefficient of variation and a favourable correlation to the control sample. This explains how CB fibre modified bitumen is suitable for use in the construction industry [7].

Md Tareq Rahman et al. (2020) this study investigated the possibility of reusing CBs that were bitumen-encapsulated in stone mastic asphalt (SMA). The bitumen class PMB A10E was used to treat and encapsulate waste CBs. Stone mastic asphalt samples were created by substituting bitumen-encapsulated CBs for coarse aggregates to the weight ratios of 1%, 2%, and 3%, respectively. The volumetric, Marshall, flow, and resilience modulus characteristics of the SMA created samples were examined, and the findings were contrasted with those of the control SMA samples made without CBs. The experimental methodologies, certain key study findings, and some findings from a leachate analysis have all been presented and discussed. According to average results, introducing encapsulated CBs to the Stone Mastic Asphalt samples created for this investigation increased their stability and resistance to permanent deformation [2].

Jimei J et al. (2019) marshall test and rutting test data to demonstrate the principle of making modified binder asphalt combination with regular asphalt mixture and to demonstrate the use of cigarette butts as a modified binder in asphalt mixture. The maximum damage load of modified asphalt pavement with cigarette butts is larger than that of unmodified asphalt pavement, showing better road anti-deforming potential. The flow value of modified asphalt pavement is lower than that of conventional asphalt pavement, indicating that it has better anti-deformation properties. Modified bituminous combinations have better high-temperature stability, anti-deformation ability, and pavement collapse strength than standard bituminous mixtures [8].

Md T.R. et al. (2019) The primary goal of this research is to evaluate the qualities of bitumen produced by combining CB with modified binder grades C320, C170, and PMB A10E. After the addition of fibres, the samples' softening point marginally lowered. Even with the decrease, it was discovered that the results still fall within the normal range and are comparable to the control sample. When comparing CB concentrations of 0.3% and 0.5%, it was shown that the mixture's softening point gradually drops as CB concentration rises. The viscosity test has improved the samples' behaviour Even though the inclusion of fibre has slightly increased the samples' viscosity in comparison to the control sample without any fibres, the results are within the range for optimum values. The fact that CBs can be a suitable material for bitumen modification is demonstrated by the physical characteristics of CB modified bitumen [1].

Abbas Mohajerani Yasin Tanriverdi. et al. (2017) In this work, the results of two investigations are presented and analysed. The effects of adding different CB concentrations to an AC mix prepared with Class 170 bitumen (10 kg/m3, 15 kg/m3, and 25 kg/m3) encapsulated with various classes of bitumen (C170, C320, and C600) were assessed in the first study. The second entailed evaluating the results of adding 10 kg/m3 of CBs encased in paraffin wax to AC mixes created using various types of bitumen (C170, and C320). Each sample, including the control AC samples (without CBs), had its mechanical and volumetric properties tested. Stability, flow, resilience modulus, bulk density, maximum density, air spaces, and voids in mineral aggregates were some of these features. Results from the first experiment using 10 kg/m3 and 15 kg/m3 of CBs in an asphalt mixture met the requirements [9].

Kavyashree.L.M. et al. (2016) use of steel slag in DBM Grade 2 as a replacement material for coarse aggregate in various sizes and percentages. It is discovered that the qualities of steel slag meet the same specifications as for crushed aggregates. Because of increased bulk density and fewer voids when 12.5mm down steel slag was added to the mix, the ideal bitumen content was decreased. Regardless of the size and proportion of the steel slag, the stability and bulk density rose as the percentage of steel slag in the mix increased. As the proportion of steel slag increases, the air spaces decrease. All the mixes' VFBs are within the permitted ranges, preventing bleeding. A value exceeding the limits is found for the indirect tensile strength ratio. When compared to combinations made with natural aggregate, steel slag mixtures with higher ITS indicate greater cohesive strength [3].

Abbas Mohajerani.et al. (2016) the study on the recycling of CBs into burned clay bricks is reviewed and some of the findings are presented in this paper. Bricks containing 2.5%, 5%, 7.5%, and 10% CB by weight were produced, tested, and contrasted with control clay bricks containing 0% CB. According to the findings, bricks with 10% CBs had a dry density drop of up to 30% and a compressive strength decrease of 88%. 19.53 Mpa was found to be the predicted compressive strength of bricks containing 1% CBs. Bricks with a 7.5% CB content were produced with various mixing times of 5, 10, and 15 minutes to examine the impact of mixing time. The production heating rate was altered to 0.7, 2-, 5-, and 10-degree C per min to examine the impact of heating time on the qualities of CB bricks. These heating rates were used to fire bricks with CB contents of 0% and 5%. Bricks having contents of 0%, 2.5%, 5%, and 10% CB underwent leachate testing. For bricks containing 0% and 5% CB, the emissions emitted during firing were examined at heating rates of 0.7, 2, 5, and 10 degrees Celsius per minute. The gases that were examined were hydrogen cyanide, carbon monoxide, carbon dioxide, chlorine, and nitrogen oxide (HCN). Finally, calculations were done to determine how much energy may be saved by firing CB-containing bricks. Up to 58% of the firing energy might theoretically be conserved, according to calculations. It has been demonstrated that using bricks to get rid of CBs is a good idea [9].

Dipu S.M. et al. (2015) The creation of a controlled void aggregate-asphalt combination is the aim of this work. The amount of filler used affects how well bituminous mixes operate. A mixture's workability is somewhat influenced by the kind and quantity of filler used. Due to the filler's potential to absorb more asphalt due to the increased surface area, the performance of the asphalt-concrete mixture may vary. The effectiveness of the mixture is also impacted by this interaction. Marshall Stability grows as asphalt cement viscosity increases. As a result, adding additional waste concrete and brick dust to the mix can provide a more viscous asphalt cement mixture binder, boosting stability. The Marshall Properties of bituminous mixes with used concrete and brick dust as fillers have been found to be remarkably similar to those of conventional (fine sand with stone dust) fillers. The maximum stability values of the mixes containing waste concrete dust and fine sand with stone dust as filler were 11.1 KN and 9.8 KN, respectively. Waste concrete dust and brick dust are appropriate as fillers as compared to the mineral filler frequently used in bituminous mixtures since they are affordable and readily available [10].

Mohd Rosli Hainin. et al. (2012) This study substituted steel slag for aggregate in normal dense graded asphalt mixtures (ACW14 and ACB28). Steel slag was chosen because it is a common by-product of the steel industry and has properties that are essentially identical to those of conventional aggregates. As control samples, the same gradations of combinations were made using regular crushed aggregate. According to Malaysian standards, samples were prepared using the Marshall mix design system. Testing procedures for asphaltic concrete samples included the rutting, creep, and resilient modulus tests. Steel slag samples exhibit notably superior results than traditional aggregate [11].

Aeslina Abdul Kadir.et al. (2012) The use of CBs in heated clay bricks was the focus of a study that is covered in this article. Different brick samples with varying CB contents were displayed together with their physical and mechanical traits. The main objective of this paper was to provide a microstructure analysis of how CB inclusion affected burnt clay bricks. The results show that the density of decreased by 8.3 to 30% when 2.5 to 10 were added to the raw materials. For CB amounts of 2.5, 5.0, and 10%, respectively, the evaluated bricks' compressive strength dropped from 25.65 MPa (control) to 12.57, 5.22, and 3.00 MPa.
The lateral modulus of rupture test findings shows that adding up to 5% of CBs has no appreciable impact on the flexural or tensile strength of bricks. The lowest flexural strength measurement was 1.24 MPa (for 10% CBs). The water absorption values increased from 5 to 18%, and the initial rate of absorption discoveries increased from 0.2 to 4.9 kg/m2 experimental mixtures [12].

Aeslina Abdul Kadir.et al. (2011) this report summarises some findings from an ongoing investigation into the conversion of CBs into baked clay bricks. Clay bricks manufactured with different CBs content (2, 5, and 10% by weight, or around 10% to 30% by volume) were mixed with the experimental soil and baked before having their qualities examined. The mixtures were produced in a 10 litre Hobart mechanical mixer for 5 minutes. Samples were made in three sizes: cube, beam, and brick with the aim of evaluating compressive strength, rupture modulus, rate of water absorption, total water absorption, and density of the manufactured bricks. Including CB in the surface and cross-sectional images of the clay-burned bricks that were put to the test. The fissures became more visible due to a rise in CB content, and the pores increased in number and size as a result [13].

Sabrina S.et al. (2011) the potential for using recyclable aggregates like steel slag to create bituminous paving mixtures The experimental inquiry involved characterising slag and bituminous mixes containing a portion of slag from a geometrical, physical, mechanical, and chemical standpoint. The findings for the fragmentation and wear resistance were satisfactory, and the figures for the water absorption and accelerated polishing coefficient were equivalent to those obtained with natural materials. The mechanical parameters of the bituminous mixtures with steel slag were on par with or even superior to those of the combinations made with natural aggregates (measured values of Marshall Stability generally higher than, average Marshall flow). Marshall stability values and indirect tensile strength were higher above the limits of acceptance, suggesting adequate mechanical resistance capabilities equivalent to the performance of typical mixtures (even after 24 hours submerged in a water bath at 60 °C). Compared to a mixture of natural aggregates, the apparent density was 7% higher [14].

Aeslina Abdul Kadir.et al. (2011) its paper summarises some findings from an ongoing investigation into the conversion of CBs into baked clay bricks. Physical and mechanical characteristics of control brick samples as well as burnt clay bricks produced with different CB percentages (2.5%, 5%, and 10%) are reported and discussed. Three various mixing times—namely, 15 minutes, 10 minutes, and 5 minutes—were tried using clay bricks that had 7.5% of CBs included in order to improve the characteristics. These adjustments' effects on physical and mechanical properties were assessed. In comparison to a 5-minute mixing period, the measurement for strength and density increased by 114% and 12%, respectively, with a 15-minute mixing time. Tensile strength, initial rate of absorption, and water absorption values, on the other hand, decreased by 22%, 29%, and 5%, respectively [15].

Aeslina Abdul Kadir.et al. (2010) The study of the transformation of CBs into burnt clay bricks is still ongoing, however some conclusions are discussed in this article. We present and discuss the physical and mechanical properties of burnt clay bricks made with varied CB content percentages. The results show that the density of burnt bricks was reduced by up to 30% depending on how many CBs were added to the raw materials. Similar to this, the quantity of CBs in the mix had an effect on the tested bricks' compressive strength. The performance of bricks in terms of heat conductivity was improved by 51 and 58% for contents of 5 and 10% CBs, respectively. To determine the amounts of probable heavy metal leachates from the created clay-CB bricks, leaching experiments were carried out [16].

Perviz A.et al. (2008) Finding out how steel slag influences the mechanical properties and electrical conductivity of asphalt concrete mixtures is the goal of this study. The following properties of four different asphalt mixtures—Marshall stability, indirect tensile stiffness, creep stiffness, moisture damage, and electrical sensitivity—were examined: (steel slag; limestone). Steel slag-containing mixtures outperformed mixes containing limestone in Marshall stability and flow trials. It is found that mixtures containing coarse aggregate made of steel slag have higher electrical conductivity than control mixtures. Due to the enhanced electrical conductivity of steel slag combinations, the thermo-electrical asphalt pavement can be utilised to create conductive asphalt concrete for de-icing parking garages, walkways, driveways, highway bridges, and airport runways. According to the investigation's findings, the steel slag mixes have excellent engineering qualities and good electrical conductivity. The asphalt combination outperformed the other studied mixtures [17].

2.1 Summary:

All This previous research concludes the use of waste material (SS, GP, CB) as they contribute in increase in various properties and enhance strength of mix shown in table 3.

Table 3: Shows the properties and results with different types of material used in previous research

S.No	Author Name	Material used in Previous Study	Properties	Results
1	Md Tareq Rahman et. al. (2020)	Cigarette butt Cellulose fiber Bitumen	Physical test Viscosity test Frequency sweep test Linear amplitude sweeps test (LAS) Marshall Stability	The penetration value increased following the addition of 0.3% cellulose fibres, but it reduced after the addition of CB. Cellulose fiber and CB viscosity are both elevated. The control sample's pattern was followed by 0.2% CB fibre modified bitumen as well. The control samples with 0% fibre exhibit higher damage intensities than the CB treated samples. The stability of SMA is not considerably impacted by the use of fibres, and CB fibre can be used in SMA without degrading performance [7].
2	Md Tareq Rahman et. al. (2020)	Encapsulated Cigarette butt Bitumen	Leachate analysis Marshall Test	When compared to the findings of the leachate analysis of used CBs performed before encapsulation, the amount of heavy metals in bitumen-encapsulated CBs has dramatically decreased. demonstrate that the encapsulating technique has reduced the average amount of heavy metal leaching by 96%. Strength increased once CBs were added to the SMA mixture. The sample's stability was raised by 2.21% when 1% encapsulated CBs (by weight) were added to SMA, and by 11.03% when 2% encapsulated CBs were added. SMA made with 1% encapsulated CB had a lower flow number than the control sample did. However, the flow number increased when 2% encapsulated CBs were used in SMA [2].
3	Jimei Jin et. al. (2019)	Cigarette butts Bitumen	Marshall Value Rutting	Increased Marshall Stability, a sign that the road's ability to resist deformation. Modified bituminous combinations have better anti-deformation, high-temperature stability, and collapse strength than regular bituminous mixtures [8].
4	Md Tareq Rahman et. al. (2019)	Cigarette butt Bitumen	Penetration Test Softening Point Test Viscosity Test	Slight decrease in the penetration. Increase in the amount of CBs in the combination causes a moderate decline in softening point, with 0.3% of the CBs having a softening point that is quite similar to the control samples. The outcomes are consistent with expected values, with the addition of fibre marginally increasing the samples' viscosity in contrast to the control sample without any fibres [1].
5	Abbas Mohajerani et. al. (2017)	Paraffin wax Cigarette butts Encapsulation Bitumen	Marshall test Volumetric properties Resilient modulus	With a stability loss of 0.38 kN for C170 and 0.57 kN for C320 brought on by the addition of 10 kg/m3 of CBs, a light traffic design would be appropriate. The criteria are not met by the medium and heavy traffic designs since the values are less than the required 6.5 kN.

				Air voids and density both decrease when CBs are introduced, however as the grade is raised from C170 to C320, the void content rises while the bulk and maximum densities only marginally decrease. As a result of the application of 10 kg/m3 paraffin-encapsulated CBs to bitumen concrete (AC), the percentage of air voids and VMA in the C170 sample reduced, however they rose in the C320 samples [9].
6	Kavyashree.L.Magadi, et. al. (2016)	Bitumen Steel slag	Marshall Value Density Indirect tensile Value	Because of increased bulk density and fewer voids when 12.5mm down steel slag was added to the mix, the ideal bitumen content was decreased. Regardless of the size and proportion of the steel slag, bulk density rose as the percentage of steel slag in the mix increased. This indicates high stiffness. In comparison to mixtures made with natural aggregate, steel slag mixtures with higher ITS indicate stronger cohesive properties [3].
7	Abbas Mohajerani et. al. (2016)	Cigarette butt Fired clay bricks	Compressive strength Modulus of rupture Water absorption	Significantly lowered from 25.65 MPa (for 0% CBs) to 12.57, 5.22, 3.00, and 3.00 MPa, respectively, for 2.5%, 5.0%, 7.5%, and 10% CB concentration. Decreased when 2.5% to 10% CBs were added to the basic materials, falling from 2.48 to 1.24 MPa. With just a rise in CB content, water absorption increased practically linearly, reaching its highest recorded value (18%) for 10% CBs. This meets with the 5-20% range of the Australian Standard (Masonry Structures, 2001) [9].
8	Dipu Sutradhar Mintu et. al. (2015)	Bitumen Brick Dust Waste concrete dust	Marshall value	The Marshall Properties of bituminous mixes containing waste bricks and concrete powder as fillers are remarkably similar to those of mixtures containing conventional (fine sand & stone dust) fillers. Brick dust was used as a filler in bituminous mixtures, which demonstrated maximum stability of 11.3 KN at 5.5% bitumen concentration. The provides excellent values of the mixes containing waste concrete dust & fine sand and stone dust as filler were 11.1 KN and 9.8 KN, accordingly [10].
9	Mohd Rosli Hainin el. al. (2012)	Steel slag Bitumen	Marshall values Resilient modulus Rutting Creep Value	The steel-slag mixture is more valuable than the typical mixture because of the higher level of pore in steel-slag aggregates. The robust modulus result is influenced by temperature as well, with steel slag combination having a greater value than conventional aggregate mix. Comparing the two mixtures, the one made with steel slag had a greater cohesive quality. Asphaltic

				concrete made with steel slag offers a greater load resistance than the standard combination. Comparing steel slag to ordinary aggregates, less persistent deformation and strain is visible. This outcome can be due to the interlocking characteristics of steel-slag, which boost the mixture's adhesion [11].
10	Aeslina A. Kadir et. al. (2012)	Cigarette butt bricks	Compressive Strength Flexural Strength Water Absorption Average Density Leaching value	For bricks with 0% CB, the compressive strength was 25.65 MPa; for bricks with 2.5, 5.0, and 10% CB, it was 12.57, 5.22, and 3.00 MPa, respectively. Bricks can include up to 5% CBs without appreciably reducing their flexural or tensile strength. Flexural strength was determined to be at 10% CBs, which is the lowest number. The water absorption values are increased from 5 to 18%, and the initial rate of absorbing discoveries improved from 0.2 to 4.9 kg/m2 /min. When using CBs in the range of 2.5 to 10%, the density of burnt bricks decreased by 8.3 to 30%. Leaching Procedure & Deductive approach Coupled Plasma Mass Spectrometer) were insignificant and well below the permitted regulatory thresholds. According to estimations, injecting 5% by weight of CBs to clay soil that has not been processed can reduce burning energy by more than 60% [12].
11	Aeslina Abdul Kadir et. al. (2011)	Cigarette butts, Fired clay brick	Compressive strength Flexural strength Water absorption	lowered at CB concentration values of 2.5, 5.0, and 10% from 25.65 MPa (control) to 12.57, 5.22, and 3.00 MPa, respectively. does not fall off much when CBs are added, even up to 5% CBs. Flexural strength measurements showed that 1.24 MPa (for 10% CBs) was the lowest value. The initial rate of results for absorption increased - 0.2 to 4.9 kg/m2 /min, as well as from 5 to 18% [13].
12	Sabrina Sorlini et. al. (2011)	Steel Slag Bitumen	Mechanical properties Chemical properties+ Volumetric expansion	Marshall test and indirect tensile test values were higher, the steel slag had a high specific gravity, and the experimental mixtures had densities that were 7-9% more than those of the conventional mixtures. The presence of steel slag caused a rise in pH, and all polluting element concentrations were much below the allowable limits. Ensure acceptable volume stability [14].
13	Aeslina Abdul Kadir et. al. (2011)	cigarette butts Bricks	Compressive strength Flexural strength Water absorption	lowered at CB concentration values of 2.5, 5.0, and 10% from 25.65 MPa (controlled) to 12.57, 5.22, and 3.00 MPa, respectively. doesn't fall off much when CBs are added, even up to 5% CBs.

				For experiment mixes, the initial absorption the often from 0.2 to 4.9 kg/m2min, while the rise in absorption rate increased from 5 to 18% [15].
14	Aeslina Abdul Kadir et. al. (2010)	Cigarette butts, Fired clay bricks, Light bricks,	Compressive strength Modulus of rupture Water absorption	lowered from 25.65 MPa (for 0% CBs) to 12.57, 5.22, and 3.00 MPa for 2.5, 5.0, and 10% CB contents, respectively. The pressure decreased from 2.48 to 1.24 MPa when raw materials were mixed with 2.5–10% CBs. The highest observed rate of water absorption (18%) was found in 10% CBs, which is within the Australian Standard's 5 to 20% range [16].
15	Perviz Ahmedzadea et. al. (2008)	Steel Slag Bitumen	Marshall stability Indirect tensile Stiffness modulus Electrical conductivity	enhanced stability and decreased flow levels. The combinations with steel slag coarse aggregate performed better than those with limestone coarse aggregate. Higher ITS enhances the cohesive strength of steel slag mixtures and boosts tolerance to moisture damage and moisture-induced rutting loss. The combinations of steel slag coarse aggregate have higher creep stiffness, which suggests superior rutting resistance. The steel slag coarse aggregate combinations' higher creep stiffness suggests improved rutting resistance [17].

3. Conclusion

1. All these preliminary researches related to the properties of CB, SS, and GP in bitumen mix conclude that the usage of this modified mixture results in more strength in flexible pavement.
2. It is found that the properties of steel slag are consistent with the specifications, that are the same as for crushed aggregates, plus they also relate to the rising cost and maintenance of distributed waste around the globe.
3. With an increase in the amount of steel slag in the mix, qualities including rutting, Marshall stability, and indirect tensile strength all improved.
4. Properties such as viscosity, Softening is increased with addition of 0.2%and 0.3% Cigarette butts and Marshall stability and rutting gives better results at 0.2% Cigarette butts.
5. The penetration test results revealed that, although a slight drop in penetration, the outcome is still very close to the bitumen's permissible range.
6. The research revealed that the interactions between different granite powders and asphalt differ noticeably. This compatibility between the asphalts and the granite powders showed that the lithofacies features of the granite have the largest influence on the moisture stability of the bituminous combinations.
7. If CB, SS, and GP are combined, the modified mixture's quality and strength would be greatly improved. This would reduce pollution, help preserve some natural resources, and lower the cost of managing nondegradable wastes.

References

[1] M. T. Rahman, A. Mohajerani, and F. Giustozzi, "Recycling cigarette butts in bitumen for flexible pavements," no. November, 2019.

[2] M. T. Rahman, A. Mohajerani, and F. Giustozzi, "Possible use of cigarette butt fiber modified bitumen in stone mastic asphalt," *Constr. Build. Mater.*, vol. 263, p. 120134, 2020, doi: 10.1016/j.conbuildmat.2020.120134.

[3] K. L. Magadi, N. Anirudh, and K. M. Mallesh, "Evaluation of Bituminous Concrete Mixture Properties with Steel Slag," *Transp. Res. Procedia*, vol. 17, no. December 2014, pp. 174–183, 2016, doi: 10.1016/j.trpro.2016.11.073.

[4] S. P. Palanisamy, G. Maheswaran, M. G. L. Annaamalai, and P. Vennila, "Steel slag to improve the high strength of concrete," *Int. J. ChemTech Res.*, vol. 7, no. 5, pp. 2499–2505, 2015.

[5] A. Chajec, "Granite powder vs. Fly ash for the sustainable production of air-cured cementitious mortars," *Materials (Basel).*, vol. 14, no. 5, pp. 1–26, 2021, doi: 10.3390/ma14051208.

[6] O. Šernas, M. Strumskys, and D. Skrodenis, "Possibility of use of granite fines in asphalt pavements," *9th Int. Conf. Environ. Eng. ICEE 2014*, no. August 2016, 2014, doi: 10.3846/enviro.2014.169.

[7] M. T. Rahman and A. Mohajerani, "Use of bitumen encapsulated cigarette butts in stone mastic asphalt," *Constr. Build. Mater.*, vol. 261, p. 120530, 2020, doi: 10.1016/j.conbuildmat.2020.120530.

[8] J. Jin, Z. Wu, J. Song, and X. Liu, "Research on the road performance of cigarette butts modified asphalt mixture," *J. Phys. Conf. Ser.*, vol. 1168, no. 2, 2019, doi: 10.1088/1742-6596/1168/2/022053.

[9] A. Mohajerani, A. A. Kadir, and L. Larobina, "A practical proposal for solving the world's cigarette butt problem: Recycling in fired clay bricks," *Waste Manag.*, vol. 52, no. October, pp. 228–244, 2016, doi: 10.1016/j.wasman.2016.03.012.

[10] D. S. Kathem Taeh Alnealy, "Effect of Using Waste Material as Filler in Bituminous Mix Design," *Am. J. Civ. Eng.*, vol. 3, no. 3, p. 88, 2015, doi: 10.11648/j.ajce.20150303.16.

[11] M. R. Hainin, N. I. M. Yusoff, M. F. Mohammad Sabri, M. A. Abdul Aziz, M. A. Sahul Hameed, and W. Farooq Reshi, "Steel Slag as an Aggregate Replacement in Malaysian Hot Mix Asphalt," *ISRN Civ. Eng.*, vol. 2012, pp. 1–5, 2012, doi: 10.5402/2012/459016.

[12] A. A. Kadir and A. Mohajerani, "Properties improvement of fired clay bricks incorporating with cigarette butts," *Adv. Mater. Res.*, vol. 535–537, no. February 2019, pp. 1723–1730, 2012, doi: 10.4028/www.scientific.net/AMR.535-537.1723.

[13] A. Kadir and A. Mohajerani, "Physical mechanical properties and microstructure analyses on effect of incorporating cigarette butts in fired clay bricks," *World J. Eng.*, vol. 9, no. 4, pp. 313–318, 2012, doi: 10.1260/1708-5284.9.4.313.

[14] S. Sorlini, A. Sanzeni, and L. Rondi, "Reuse of steel slag in bituminous paving mixtures," *J. Hazard. Mater.*, vol. 209–210, pp. 84–91, 2012, doi: 10.1016/j.jhazmat.2011.12.066.

[15] A. A. Kadir and A. Mohajerani, "Properties improvement of fired clay bricks incorporating with cigarette butts," *Adv. Mater. Res.*, vol. 535–537, pp. 1723–1730, 2012, doi: 10.4028/www.scientific.net/AMR.535-537.1723.

[16] A. A. Kadir, A. Mohajerani, F. Roddick, and J. Buckeridge, "Density , Strength , Thermal Conductivity and Leachate Characteristics of Light-Weight Fired Clay Bricks Incorporating Cigarette Butts," *World Acad. Sci. Eng. Technol. Int. J. Civil, Environ. Struct. Constr. Archit. Eng.*, vol. 3, no. 5, pp. 242–247, 2009.

[17] P. Ahmedzade and B. Sengoz, "Evaluation of steel slag coarse aggregate in hot mix asphalt concrete," *J. Hazard. Mater.*, vol. 165, no. 1–3, pp. 300–305, 2009, doi: 10.1016/j.jhazmat.2008.09.105.