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Paving the Way for Sustainability: A Study on Porous Asphalt Mixtures Reinforced with LDPE Plastic Waste and Freshwater Mussel (Pilsbryoconcha Exilis) Shell Filler

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Abstract

This study aimed to explore the impact of different fillers, namely conventional (stone ash) and alternative (mussel shell powder), along with varying percentages of Low-Density Polyethylene (LDPE) additives, on the performance of porous asphalt mixtures. Asphalt mixtures' Marshall Stability and Flow were examined with LDPE percentages of 0%, 2%, 4%, and 6%. Results highlighted that the choice of filler and LDPE content significantly influences the mixture's stability and flow. A shift from 100% stone ash to 50% mussel shell powder resulted in a slight decrease in stability for 0% and 2% LDPE. In contrast, the stability was notably higher for 4% and 6% LDPE, including the alternative filler. Mixtures with 100% stone ash exhibited increased flow values with rising LDPE concentrations, while mixtures with 100% mussel shell powder showed an opposite trend. Furthermore, mixtures containing mussel powder generally had higher flow values than those with stone ash at similar LDPE percentages. The study underscores the intricate relationship between filler types and LDPE additives in influencing the properties of asphalt mixtures. These findings pave the way for the potential use of alternative fillers in asphalt mixtures, emphasizing the importance of understanding material interactions for optimal pavement design.

1. Introduction

The construction and maintenance of resilient roadways are pivotal in contemporary society. They facilitate the movement of goods, people, and services across regions, fostering economic growth and social development. However, countries such as Indonesia, which experience high rainfall, need substantial help in preserving the quality and longevity of their roadways. The accumulation of water on road surfaces leads to the gradual deterioration of the pavement structure, compromising the overall integrity of the road and significantly increasing the risk of accidents due to poor road conditions. Consequently, an urgent and pressing demand exists for innovative solutions that can effectively manage water drainage on road surfaces while simultaneously ensuring the durability and optimal performance of the pavement.

Porous asphalt mixtures have emerged as an up-and-coming solution to address these challenges. Despite their potential, conventional porous asphalt mixtures possess certain drawbacks that necessitate the exploration and development of modified asphalt mixtures capable of overcoming these limitations. One approach that holds great promise in achieving this objective involves incorporating alternative materials, including waste materials, into the asphalt mixture. This strategic and innovative approach has the potential to enhance roadways' overall performance and durability significantly. It has the added benefit of reducing the environmental impact of road construction activities.

Previous investigations have delved into using porous asphalt mixtures in road construction, explicitly focusing on the manifold advantages they offer regarding water management and enhanced safety. These advantages manifest in reduced water splashing and spraying during rainy seasons, mitigating hydroplaning and bolstering skid resistance risk, ultimately resulting in safer driving conditions [1]. This is achieved by decreasing the impact of tires on the road pavement, thereby minimizing the generation of traffic noise. The salient feature of porous asphalt lies in its pore structure, which facilitates the swift drainage of water from the road surface, effectively eliminating the phenomena of splash and spray. This assertion is supported by research conducted by Zhu et al. [2]. Another noteworthy finding emerging from scientific inquiry is that a significant proportion, approximately 20%, of road accidents occur under wet weather conditions. Furthermore, it has been ascertained that the level of skid resistance on wet pavements plays a pivotal role in determining the frequency and occurrence of such incidents. These observations have been substantiated by the work of Fwa [3].

However, it is essential to acknowledge that using porous asphalt mixtures also entails specific challenges that must be addressed. One such challenge is the reduced durability and stability associated with these mixtures. For instance, research by Akhtar et al. [4] indicates that porous asphalt exhibits a shorter lifespan than its compact counterpart, primarily due to its inherent vulnerability to disintegration. Moreover, another study highlights the significant role played by the asphalt binder in determining the overall durability of the porous asphalt mixture, as it can lead to the deterioration of the mix [5].

To optimize the performance of porous asphalt mixtures, researchers have dedicated their efforts to exploring the incorporation of waste materials in the construction process. Using waste materials in road construction has garnered immense attention owing to its potential to offer environmentally friendly and economically viable alternatives to traditional materials. This avenue of inquiry has witnessed extensive research, encompassing a wide range of waste materials, including plastic waste, industrial by-products, and recycled construction materials. These materials have been investigated as sustainable solutions for developing durable roadways. Dimter et al. [6] have been at the forefront of this research endeavor. In a similar vein, the utilization of waste materials has also been explored as a means to address the challenges above associated with porous asphalt mixtures. This novel approach has the potential to not only enhance the durability and stability of these mixtures but also contribute to the overall sustainability of road construction. This line of inquiry has been pursued by Lamba et al. [7] and Nyika & Dinka [8].

Low-density polyethylene (LDPE) is a widely utilized plastic material in numerous applications, ranging from packaging materials to agricultural films and disposable containers. However, the improper disposal of LDPE plastic waste has given rise to significant environmental issues, including pollution and a shortage of available landfill space. Consequently, incorporating LDPE plastic waste into porous asphalt mixtures offers a promising opportunity to address these pressing environmental concerns while enhancing roadways' performance and durability. Previous research endeavors have illuminated the positive impact of incorporating LDPE plastic waste as an asphalt additive on the overall properties of the modified binder. These beneficial effects encompass increased viscosity, stiffness, and resistance to aging. By replacing virgin polymers with waste plastics in the asphalt modification processes, it is conceivable to reduce overall costs without compromising the performance of the asphalt.

Moreover, a recent study has also discovered that including LDPE plastic waste in asphalt mixtures can augment stiffness and improve various properties [9]. Furthermore, another investigation has demonstrated that using electronic waste plastics as additives for asphalt binders can decrease temperature susceptibility and enhance rheological characteristics [10]. As if these findings were not compelling enough, incorporating LDPE plastic waste into porous asphalt mixtures has exhibited enhanced stability, reduced susceptibility to moisture damage, and improved fatigue resistance [11]. These significant findings strongly indicate that the utilization of LDPE plastic waste as an additive in porous asphalt mixtures aligns with the stringent criteria set forth by Marshall's mix design.

The amount of research conducted on using waste shells from freshwater mussels (pilsbryoconcha exilis) as a substitute for fillers in asphalt mixtures currently needs to be expanded in scope. However, studies have been conducted on using similar waste materials, such as oyster shells and clamshells, which have yielded promising results regarding pavement's mechanical properties and environmental impact. For instance, the utilization of waste faunus atter shell powder (FASP) as a replacement for stone dust as a filler has been shown to have a positive influence on both the permeability and VIM (voids in mineral aggregate) of porous asphalt mixtures [12]. Furthermore, it has been observed that the presence of calcium carbonate in oyster shells can react with the asphalt binder, thereby positively affecting the stiffness and strength of the asphalt mixture [13]. Additionally, it is worth noting that calcium carbonate is widely employed in various industries, including construction materials, food supplements, pharmaceutics, animal feed, and plastic production industries. This compound can be obtained from marine waste materials, such as shells from crustaceans and bivalves [14]. Moreover, a study conducted by Iriani & Hasan [15] has revealed that freshwater mussel shells possess a higher calcium content, precisely 61.4%, when compared to oyster shells, which have a calcium content ranging from 31.8% to 39.9% [16], or Chinese pond mussels, which have a calcium content of 26.60% [17]. These research findings suggest that incorporating waste shells from freshwater mussels could serve as an alternative filler in asphalt mixtures, offering an alternative to traditional additives.

Although previous investigations have explored the utilization of waste materials in road construction and porous asphalt mixtures, the comprehension of the potential advantages and disadvantages of incorporating LDPE plastic waste and freshwater mussel shell waste into these mixtures still needs to be improved. It is imperative to bridge this research gap to ascertain the most optimal amalgamation of waste materials to augment roadways' performance, durability, and sustainability while minimizing the adverse environmental impact often associated with road construction endeavors. Furthermore, it is imperative to delve into the ramifications of varying concentrations of these waste materials on the properties of porous asphalt mixtures, encompassing the vital aspects of Marshall stability and flow.

The primary objective of this study is to investigate the effects of LDPE waste on the Marshall characteristic values of porous asphalt mixtures. Concurrently, it delves into understanding the viability of freshwater mussel shell waste as an alternative filler for these mixtures. The research methodology encompasses a series of laboratory tests designed to measure the Marshall characteristic values of porous asphalt. These tests incorporate varying concentrations of LDPE plastic waste and freshwater mussel shell waste. Following this, the characteristics of the asphalt mixtures, notably their stability and flow, are evaluated. The culmination of this methodology involves a comprehensive analysis of the findings, highlighting the characteristics and interrelationships between the concentrations of the waste materials and the properties of the asphalt mixtures. By examining the effects of incorporating LDPE plastic waste and freshwater mussel shell filler on the performance of porous asphalt mixtures, the research seeks to offer valuable insights that can contribute to developing sustainable and environmentally friendly road construction practices. The findings of this study have the potential to improve the durability and sustainability of roadways in Indonesia and contribute to the broader efforts to promote environmentally responsible infrastructure development worldwide.

The primary aim of this study is to thoroughly investigate and examine the various effects that the waste material known as LDPE (low-density polyethylene) has on the Marshall characteristic values of porous asphalt mixtures. Simultaneously, it delves deep into understanding and comprehending the feasibility and practicality of utilizing freshwater mussel shell waste as an alternative filler for these mixtures. The research methodology employed for this study encompasses a well-designed and planned series of laboratory tests, all with the specific purpose of accurately measuring and quantifying the Marshall characteristic values of the porous asphalt. These tests are carefully and systematically conducted using an array of asphalt mixtures that incorporate varying concentrations of LDPE plastic waste and freshwater mussel shell waste. Following this, the characteristics of the asphalt mixtures, most notably their stability and flow properties, are assessed and evaluated using exact and accurate measurement techniques. The culmination of this rigorous and comprehensive methodology involves an in-depth and detailed analysis of the obtained findings, emphasizing highlighting and elucidating the various characteristics and interrelationships between the concentrations of the waste materials and the properties of the asphalt mixtures by thoroughly examining and scrutinizing the effects and outcomes of incorporating LDPE plastic waste and freshwater mussel shell filler into the performance of porous asphalt mixtures, the research endeavors to provide and disseminate valuable and insightful knowledge that can significantly contribute to the ongoing development and advancement of sustainable and environmentally friendly road construction practices. Ultimately, the ultimate goal and objective of this study is to enhance and improve the durability, longevity, and sustainability of roadways in Indonesia specifically while simultaneously making a substantial contribution to the broader global efforts and initiatives to promote and foster the development and construction of environmentally responsible and sustainable infrastructure worldwide.

2. Materials and Methods

2.1. Materials

Table 1 comprehensively presents the fundamental characteristics of the asphalt binder examined in this study, employing the testing methodology endorsed by the esteemed American Society for Testing and Materials (ASTM). The properties subjected to testing and listed include the penetration value at 25°C, the softening point, the specific gravity, and the ductility at 25°C. In the subsequent section, an in-depth analysis of this material will be conducted based on the provided data. The asphalt binder, a material of paramount importance in the construction industry, particularly in road paving, exhibits a highly commendable penetration value of 67.3 (0.1mm). This property is a testament to its remarkable ability to endure the imposed load from vehicular traffic without succumbing to cracks.

Moreover, the value that has been provided signifies the presence of a relatively soft binder, thereby rendering it highly suitable for deployment in regions characterized by moderate climates. Furthermore, the softening point of the asphalt binder has been determined to be 53.5°C, indicating its capacity to effectively withstand the process of softening, even in the face of relatively elevated temperatures. Consequently, this material can be deemed highly advantageous and utilitarian in regions that typically experience warm climates. The specific gravity of the asphalt binder, as established at 1.04, reveals its minuscule denseness relative to water. This particular attribute of the binder exerts a notable influence on the overall weight of the asphalt mixture and, in turn, significantly impacts the load that road structures bear.

Consequently, it becomes clear that this particular characteristic plays an indispensable role in the processes associated with the design and construction of roads. Lastly, the material's ductility, quantified at 125 cm at 25°C, impeccably showcases its capacity to undergo deformation in the presence of stress without succumbing to cracks. This invaluable quality becomes especially pertinent in light of its ability to effectively absorb and mitigate the deleterious impacts caused by the stresses emanating from both vehicular traffic and fluctuations in temperature.

Table 1 *Basic properties of asphalt binder*

Properties	Test Result	Method
Penetration 100 g for 5 s at 25°C (0.1 mm)	67.30	ASTM D5
Softening point (°C)	53.50	ASTM D36
Specific gravity (gr/cm^3)	1.04	ASTM D79
Ductility at 25°C (cm)	125.00	ASTM D113

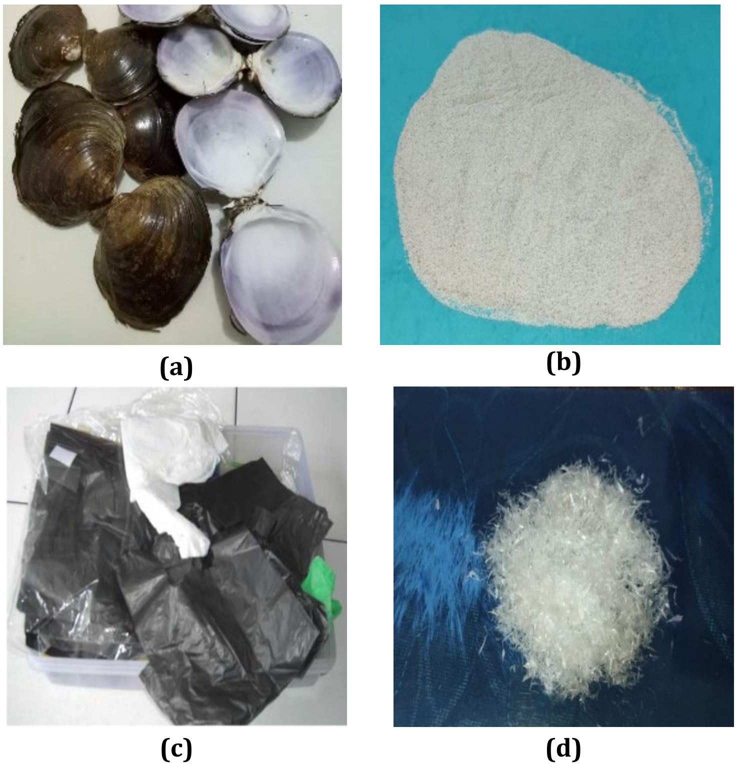
Table 2 presents a comprehensive overview of the aggregate's fundamental characteristics employed in this study. The density value is 2.64 grams per cubic centimeter, which signifies a moderate density. This implies that the aggregates possess a weight-to-volume ratio that is reasonably favorable, rendering them suitable for a variety of applications necessitating a specific density. The aggregates manifest a relatively diminutive absorption percentage of 0.50%. This signifies that they exhibit commendable resistance to the absorption of moisture. This trait can prove advantageous when moisture resistance, such as concrete production, is an indispensable prerequisite. Abrasion and impact values furnish invaluable insights into the durability of the aggregates. With an abrasion percentage of 31.67% and an impact percentage of 16.49%, these materials exhibit a moderate resistance to wear and a moderate resistance to impact. Although they may not possess extraordinary durability, they can still be deemed suitable for construction purposes wherein moderate strength is acceptable. The flakiness and elongated indices serve as indicators of the shape characteristics of the aggregates. A lower flakiness index of 8.73% implies that the materials harbor a relatively higher proportion of particle sizes that closely approximate their thickness, thereby reducing the likelihood of the occurrence of flat and elongated particles. Similarly, the elongated index of 12.60% denotes a moderate quantity of elongated particles. These attributes are paramount in applications such as asphalt mixtures, wherein well-graded aggregates featuring a low proportion of flaky and elongated particles are coveted.

Table 2 *Basic properties of aggregate*

Properties	Test Result	Method
Relative density (gr/cm3)	2.64	ASTM C127
Absorption (%)	0.50	ASTM C127
Abrasion (%)	31.67	ASTM C131
Impact (%)	16.49	ASTM C131
Flakiness index (%)	8.73	ASTM D4791
Elongated index (%)	12.60	ASTM D4791

The mussel shells were collected from a restaurant in the city of Meulaboh, which is located in the West Aceh region. To commence the processing of the collected Kijing Clam shells, an initial stage of cleaning is conducted to effectively eliminate any traces of attached dirt that may be present. Following this, the shells are subjected to sun-drying, leaving them to dry at the surrounding ambient temperature until they have reached a state of complete dryness. Once the desired dryness level has been attained, the dried Kijing Clam shells are ground using the Cantabro Loss (CL) machine. This machine is specifically designed to ensure that the shells are ground to the desired fineness, resulting in a texture that is deemed satisfactory. To further refine the ground shells, they are passed through a No.200 sieve (0.075 mm) to ensure that any remaining particles are effectively removed. Once this step has been completed, the processed shells are carefully placed in an oven and exposed to a controlled temperature of 300ºC for three hours. Subjecting the shells to this specific temperature enables them to undergo a transformative process, ultimately enhancing their overall quality and properties. To visually observe and analyze the changes between the shells before and after the grinding process, a comparison can be made by referring to Fig. 1, displayed below.

In the composition of the asphalt and aggregate blend, waste LDPE is included in three variations, namely 2%, 4%, and 6%. The decision to incorporate LDPE sourced from domestic waste or similar outlets is executed randomly, predicated upon the state and cleanliness of the material. To facilitate the process of amalgamation with the asphalt, it becomes imperative to cut the LDPE plastic waste using cutting implements such as scissors or alternative tools, ensuring that the material can penetrate a No. 4 sieve (5 mm) while remaining trapped within a No. 16 sieve (1.18 mm). Subsequently, the material is quantified commensurate with the percentage of the mixture and added to the heated asphalt at a temperature of 150°C. The LDPE is combined with the asphalt until the entirety of the LDPE waste has dissolved seamlessly into the asphalt. Herein exemplifies LDPE plastic waste derived from household waste, severed through a No. 4 sieve and retained within a No. 16 sieve.



(a) (b)

(c) (d)

Fig. 1 *The waste additive used as (a) Mussel shell; (b) Mussel shell powder filler; (c) LDPE waste; (d) LDPE waste additive*

2.2. Marshall Parameter Analysis

The Marshal parameters were analyzed to assess and evaluate the critical attributes of the asphalt mixture, encompassing both stability and flow. These parameters play a pivotal role in providing essential insights into the overall performance and quality of the asphalt mixture, catering to a wide range of applications. Stability, as a critical parameter, serves as a measure to gauge the ability of the asphalt mixture to withstand deformation when subjected to applied loads. It essentially signifies the capacity of the mix to endure traffic loads without experiencing any form of permanent deformation. A higher value in terms of stability is deemed desirable, as it suggests a more robust and resilient pavement structure.

On the other hand, the flow parameter evaluates the asphalt mixture's ability to deform under load. It reflects the lateral spreading or deformation of the mix when subjected to a load. The presence of adequate flow is crucial as it ensures that the mixture can accommodate any imposed stresses and effectively distribute them, thus minimizing the likelihood of cracks or rutting. Analyzing these Marshal parameters plays a vital role in assessing the performance characteristics and suitability of the asphalt mixture for specific applications. It empowers engineers and researchers to make informed decisions on the design, construction, and maintenance of pavements, ultimately guaranteeing the provision of safe, durable, and long-lasting road infrastructure.

3. Results and Discussion

3.1. Marshall Stability

The variability in the Marshall Stability of the asphalt mixture with changes in the composition, which can be observed in Fig. 2, serves as an illustrative example. The findings obtained from the experiments strongly suggest that the selection of filler, regardless of whether it is conventional or alternative, as well as the proportion of LDPE, added to the mixture, exerts a significant influence on the stability of the mix. Notably, all the mixtures display a noticeable impact of the LDPE percentage on the Marshall Stability. Nonetheless, it is essential to emphasize that the stability of the mix does not follow a straightforward linear increase or decrease pattern as the LDPE percentage increases. Instead, the trend of stability seems to exhibit variations depending on the specific composition of the mixture, which in turn implies the existence of a complex interaction between LDPE and the other components.

When comparing mixtures containing different fillers, it was observed that there was a shift from utilizing 100% conventional filler, specifically stone ash, to incorporating 50% alternative filler, which is mussel powder. This shift slightly decreased the Marshall Stability for mixtures containing 0% and 2% LDPE. However, when the LDPE content was increased to 4% and 6%, the stability of the mix with 50% alternative filler was higher than that of the mixture with 100% conventional filler. To investigate the impact of alternative fillers further, the filler's proportion was increased to 100%. Remarkably, the Marshall Stability increased for the mixtures containing 0% and 2% LDPE, and the subsequent increase was 4% LDPE, compared to the mix with 50% alternative filler. However, it is interesting to note that the stability of the mixture with 6% LDPE was lower when the alternative filler was increased to 100% compared to the mix with 50%. These findings highlight that the proportion of the filler determines the effect of the alternative filler on Marshall Stability not solely by the amount of LDPE present in the mixture but also by the amount of LDPE present.

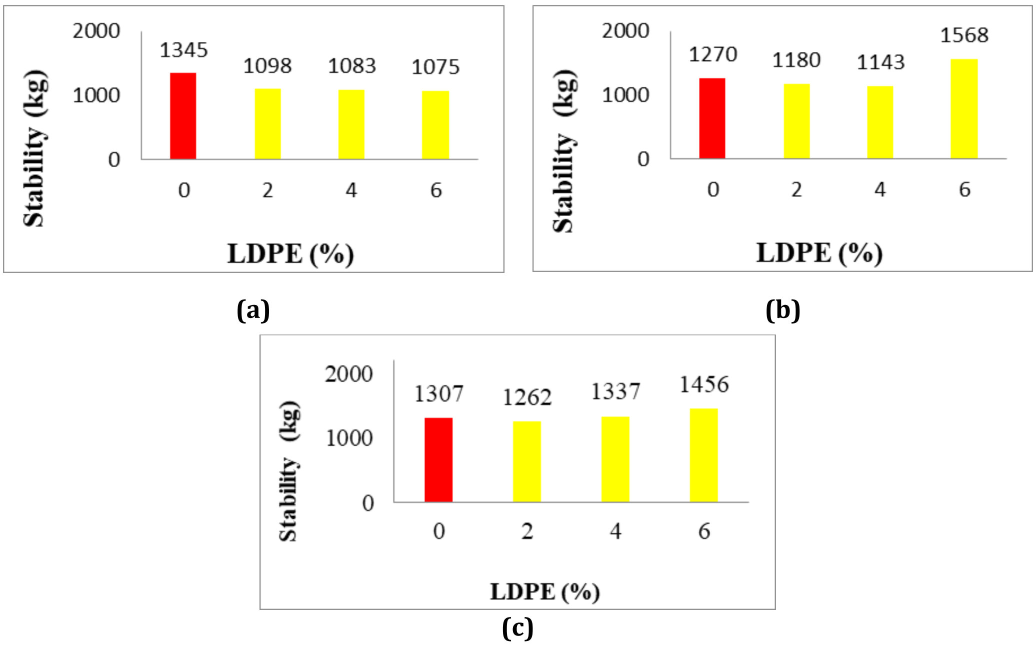


Fig. 2 *Marshall stability test results (a) 0% MSP: 100% SA; (b) 50% MSP: 50% SA; (c) 100% MSP : 0% SA*

While it is impossible to definitively determine specific mechanisms based solely on the data presented in this study, it is still possible to engage in speculative analysis by drawing upon our knowledge of the known characteristics of the materials involved. The presence of LDPE in the mixture may serve as a binder, thereby enhancing the overall cohesion of the mix. However, it is essential to note that the physical and chemical properties of the filler material used in the mixture may significantly impact its effectiveness. For instance, mussel shell powder, considered an alternative filler, may possess different particle sizes, shapes, or chemical compositions compared to the conventional filler, stone ash. These differences could influence how mussel shell powder interacts with LDPE and other components within the mixture.

Despite the relatively modest size of the dataset, there are indications of interactions and potentially intricate correlations between the variables of interest, namely filler type, LDPE percentage, and Marshall Stability. The trends observed in the data imply that the effect of one variable on the outcome may be contingent upon the levels of the other variables. To illustrate, an increase in the percentage of alternative filler generally leads to a rise in Marshall Stability at lower LDPE levels. However, the relationship becomes more intricate as the LDPE levels increase. Future investigations could explore additional factors such as the particle size and shape of the fillers, the influence of diverse LDPE grades, and the impact of environmental conditions during testing, including temperature. Consequently, based on the evidence provided by the data, it is evident that both the choice of filler and the percentage of LDPE have a significant impact on the Marshall Stability of the porous asphalt mixture. Furthermore, the observed trends suggest that the interaction between these factors is intricate and contingent upon the specific proportions and characteristics of the materials involved.

Overall, the findings presented in this study offer a hopeful and auspicious glimpse into the potential application of alternative fillers and additives in asphalt mixtures. It is crucial, however, to underscore the need for further investigation to arrive at more robust and comprehensive conclusions and optimize the mix proportions. This additional research endeavor may encompass a more expansive and extensive series of tests involving varying proportions of filler and LDPE alongside a thorough examination of the physical and chemical attributes of the fillers. Moreover, it is critical to explore the utilization of advanced analysis techniques to delve deeper into the underlying mechanisms and acquire a more profound understanding of the phenomenon at hand.

3.2. Marshall Flow

Fig. 3 visually presents the Marshall flow values for various asphalt mixtures, measured in millimeters (mm). It is important to note that the influence of LDPE content on the flow values is contingent upon the specific type of filler incorporated into the mixture. In the scenario where 100% Stone Ash is utilized, it becomes apparent that an increase in the percentage of LDPE leads to an overall augmentation in the Marshall flow values. This observation strongly implies a positive correlation between LDPE and the flow value when combined with pure stone ash. However, when equal quantities of mussel powder and stone ash are employed, the rise in LDPE percentage fails to exhibit a discernible pattern in the flow values. This finding suggests that LDPE's effect on the flow values becomes less predictable when both fillers are equally represented in the mixture. On the contrary, if the mixture solely consists of 100% mussel powder filler, it is generally observed that the flow values tend to decrease as the LDPE content increases. This provides evidence for an inverse relationship between LDPE and flow values in situations where stone ash is absent from the mixture.

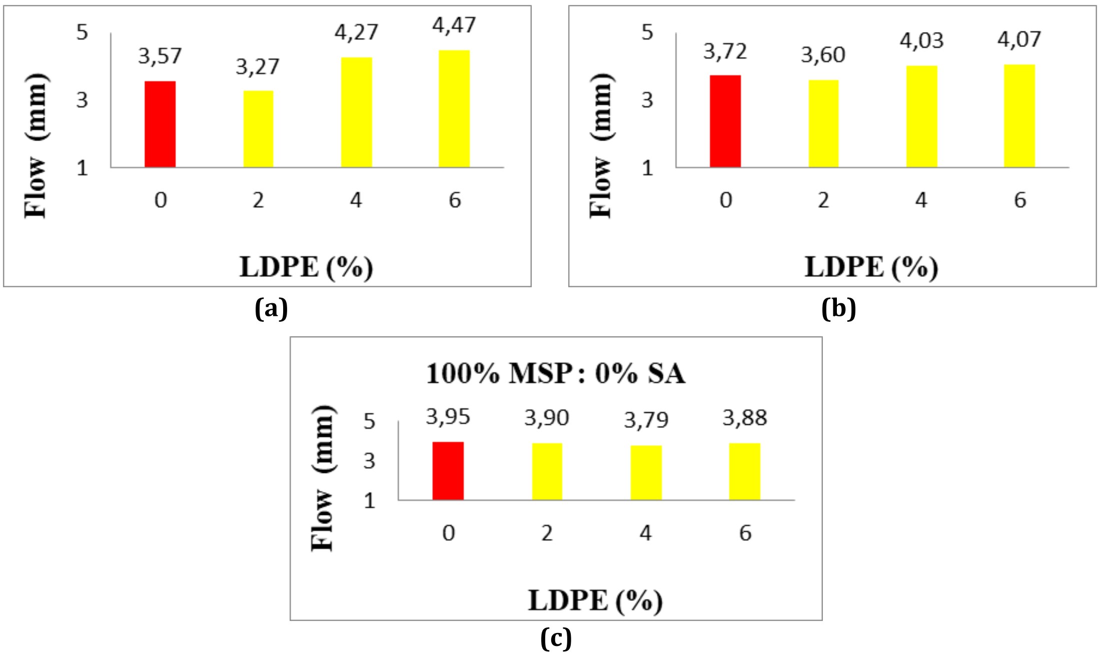


Fig. 3 *Marshall flow test results (a) 0% MSP: 100% SA; (b) 50% MSP: 50% SA;* (c) 100% MSP: 0% SA

The type of filler used significantly impacts the effect of LDPE. It is observed that when stone ash is the sole filler, higher concentrations of LDPE are found to have a positive correlation with increased flow values. Conversely, increased LDPE content decreases flow values when mussel shell powder is the only filler. Utilizing mussel shell powder as an alternative filler has a noteworthy effect on the Marshall flow value. Mixtures containing 100% mussel powder exhibit higher flow values than those with 100% stone ash at the exact LDPE percentages. This implies that mussel powder may contribute to a more fluid mixture, possibly due to its distinctive physical or chemical properties, such as particle size, shape, or mineral composition.

These findings offer invaluable and thought-provoking information about the intricate and multifaceted connections between the specific types of fillers utilized (namely, stone ash or mussel powder) and incorporating LDPE additives within porous asphalt mixtures. As such, they underscore the imperative nature of conducting additional investigations and engaging in further research and development within this field of study to gain a more comprehensive understanding of how alternative fillers can influence the various properties exhibited by asphalt mixtures.

4. Conclusion

The discoveries made in this investigation provide evidence that the selection of filler and the proportion of low-density polyethylene (LDPE) significantly influence the Marshall Stability and Marshall flow of porous asphalt mixtures. Introducing an alternative filler, specifically mussel shell powder, demonstrates promising advantages in improving stability and flow values, especially with low LDPE percentages. However, it is crucial to note that the interaction between LDPE and the fillers is intricate and displays variations depending on the specific ratios and characteristics of the materials involved. These findings make a valuable contribution to the existing body of knowledge in the field by shedding light on the impact of alternative fillers and LDPE additives on the performance of asphalt mixtures.

The study's findings reveal that the influence of LDPE on Marshall Stability is significantly affected by the type of filler utilized in the mixture. In situations where stone ash is employed as the sole filler material, it can be observed that the introduction of LDPE generally reduces the overall stability of the mixture. However, the presence of an alternative filler, such as mussel powder, adds a layer of complexity to the relationship between LDPE and stability, as it is found to exert a non-linear effect on the overall strength of the mixture. Additionally, it is worth noting that the impact of LDPE on Marshall flow, another crucial parameter, also exhibits variations depending on the specific filler type employed. In mixtures where stone ash is utilized as the filler, the introduction of LDPE results in an increase in the flow values. On the other hand, when mixtures incorporate mussel powder as the filler, LDPE has been found to contribute to a decrease in the flow values.

The findings highlighted in this study emphasize the necessity for additional research endeavors to optimize the proportions of mixtures and enhance our understanding of the fundamental mechanisms governing them. Future investigations must consider various factors, including but not limited to the particle size and shape of the fillers, the potential variations in LDPE grades, and the environmental conditions that prevail during testing. Furthermore, this study sheds light on the importance of considering other performance characteristics, such as the durability and resilience of these mixtures in the face of environmental challenges and their economic feasibility, in any forthcoming research endeavors.

The findings presented in this study significantly contribute to the overall comprehension and knowledge surrounding the utilization of alternative fillers and additives in asphalt mixtures. Specifically, implementing mussel shell powder as a substitute filler exhibits promising potential in the enhancement of the performance of the mix. However, to arrive at more robust and conclusive determinations, further investigations and examinations must be conducted, thereby enabling the optimization of mixture proportions. Consequently, by addressing and delving into these existing research gaps, it will be feasible and achievable to propel and advance the ongoing development and evolution of more sustainable and long-lasting asphalt mixtures.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm their contribution to the paper: ***study conception and design:*** *F. Rachman, T. Syammaun;* ***data collection:*** *F. Munanda;* ***analysis and interpretation of results:*** *F. Rachman;* ***draft manuscript preparation:*** *M. Syahbana. All authors reviewed the results and approved the final version of the manuscript.*

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