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RESEARCH ARTICLE

Engineering Properties of Asphaltic Concrete Modified with Waste Engine Oil

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ABSTRACT - The depletion of crude oil reserves has spurred the search for alternative resources for road construction. The use of waste engine oil (WEO) in asphalt binders and mixtures is investigated in this study, focusing on the performance of WEO-modified mixtures and their possible advantages for the environment and the economy. This study evaluates the effects of WEO at four replacement levels: 0.2%, 0.4%, 0.6%, and 0.8% by weight of bitumen. The primary goals are to measure the mechanical performance of asphalt mixtures containing WEO, determine the ideal WEO percentage, and evaluate the physical characteristics of a binder modified with WEO. The methodology includes evaluating the performance of the asphalt mixture, the properties of the binder and aggregates, and determining the optimum bitumen content (OBC). Key tests conducted in this study are the Marshall Stability and Flow tests for the asphalt mixture, the Penetration and Softening Point tests for binder characterization, and the Los Angeles Abrasion and Aggregate Crushing Value tests for assessing aggregate quality. The findings show that although WEO can affect asphalt performance, the right balance is crucial. At 0.2% WEO, the asphalt mixture achieved the highest Marshall Stability (17.71 kN) and acceptable flow value (3.1 mm), indicating improved durability and flexibility. Although, higher WEO content softens the binder further, it compromises mechanical strength. Higher WEO content led to lower stiffness and reduced load-bearing capacity. To support Malaysia's sustainable infrastructure and environmental preservation, this study attempts to optimize WEO usage. Thus, 0.2% WEO is recommended as the optimum dosage for modified bitumen to achieve enhanced pavement performance while promoting recycling of hazardous waste.

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1. INTRODUCTION

In many countries, the amount of public road networks, especially highways, has grown significantly in the last few decades. In Malaysia, the transportation sector is rapidly evolving with the expansion of highways, incorporating advanced construction technologies and Intelligent Transportation Systems (ITS) to improve efficiency and sustainability, in line with the Green Technology Master Plan Malaysia (GTMP) 2017–2030 [1]. As road networks continue to expand and modernize, regular maintenance has become increasingly important to maximize the social and economic benefits of roads and improve their functionality. Pavement problems like cracks, ruts, settlements, and potholes are becoming more common as a result of the increasing number of vehicles on the road each year. Pavement deterioration is primarily influenced by heavy traffic loads, moisture infiltration, subgrade strength, and maintenance quality [2]. Frequent axle load applications cause structural deterioration, and moisture intrusion causes material displacement and strength loss. Furthermore, poor subgrade support and neglected maintenance hasten pavement failures like ruts, settlements, and cracks, which shortens the pavement's lifespan and reduces its ability to support loads.

Engine oil, also known as motor oil or crankcase oil, is necessary for lubricating, shielding, cleaning, lowering friction, and stopping corrosion in engine components. Large-scale industrial manufacturing is replacing agriculture as the main driver of Malaysia's economy. Currently there are 23 million registered vehicles in Malaysia and all those vehicles have contributed to the generation of waste engine oil (WEO), which is the excess of oil manufactured for use in machinery and automobiles [3]. Generally, larger engines generate WEO at a higher number compared to smaller vehicle engines but this is due to often higher wear and tear of larger engines, as oil changes are frequent. All active forms of transportation together account for an approximate annual total of 150 million liters of waste lubricating oil produced from the shipping and land transport of goods alone, as there are more vehicles on the road altogether.[3]

Because of contamination from dirt, water, salt, and metals, WEO has to be replaced often in every type of operational equipment [4]. One of the primary factors is that high levels of WEO can gradually corrode engine parts as acidity is very high, oxidation and built-up contaminants heighten oil viscosity and diminish its lubricating ability. Apart from that, engine oil is categorized as hazardous waste, and improper disposal can contaminate water sources, endanger wildlife, and contribute to soil pollution [5], as it contains harmful contaminants such as heavy metals, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and glycol, which pose significant risks to both the environment and human health [6]. Long-term effects can result from even a tiny quantity. To maintain optimal engine functionality and prevent pollution of the environment, waste engine oil must be disposed of or reused properly by both individuals and businesses.

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Since oil does not break down but instead becomes contaminated over time, WEO should be disposed of properly through recycling. The recycling process of WEO consists of several steps to ensure safe handling and environmental sustainability [7]. The oil should first be drained and transferred into a sealed container, such as a metal can or plastic jug, to prevent spills or leaks. After that, waste oil is gathered and recycled at a large number of auto repair shops and supply stores. Additionally, by collecting different kinds of machine oils, such as gear lubricants, hydraulic oil, crankcase oil, and transmission fluid, hazardous waste collection programs play a critical role in environmentally responsible disposal.

Mineral oil, including the engine oil used in vehicles, can be seen as a renewable resource provided that it is properly recycled. The process of refining is one of the well-known processes for recycling WEO. The re-refining process begins with 'dewatering', which is the removal of unnecessary water in the oil [8]. It then goes through the process of demineralization and filtration for removal of solid contaminants and impurities. Propane deasphalting separates the heavier bituminous parts from the oil. In the distillation stage, it produces a refined end product that is capable of being used in various industry applications. Additionally, WEO can be repurposed as a bitumen modifier used in road pavement applications. WEO and its derivatives have gained short significance recently as effective asphalt modifiers as the constituents of asphalt and WEO are relatively similar [9]. Due to their similar hydrocarbon-based compositions, asphalt and WEO can be blended chemically. WEO can effectively blend with bitumen thanks to this similarity, improving its qualities without substantially changing its structure. Petroleum resources can be preserved by recycling and reusing spent engine oil, which lessens the need for virgin crude oil, which needs intensive extraction, processing, and refining [10]. Recycling is therefore a more environmentally friendly method of supplying the market for industrial lubricants while simultaneously preserving finite natural resources and lowering the negative effects of crude oil extraction on the environment, including habitat loss, water contamination, and carbon emissions.

This study aims to evaluate the efficacy of WEO in hot mix asphalt (HMA) as a sustainable and eco-friendly solution. Lowering the bitumen's workability temperature, improving HMA's capacity for self-healing, and reducing the bitumen content are among the secondary goals.

2. METHODS AND MATERIALS

This section explains the experiment's steps, such as how the WEO sample is prepared, what tools are used, and how much of the design mix is replaced with WEO. To assess the effectiveness of asphalt mixture incorporating WEO, ten samples each of the aggregate test (Los Angeles Abrasion Value, Aggregate Crushing Value, and Sieve Analysis), bitumen test (Penetration and Softening Point Test), and Marshall Stability were carried out. The ideal bitumen concentration and aggregate gradation were established to produce controlled and modified bitumen and asphalt mixtures with satisfactory outcomes.

2.1 Materials

2.1.1 Bitumen

The bitumen used had a penetration grade of 60/70 and was supplied by Exclusive Alfa Enterprise. Bitumen 60/70 is chosen as it is the type of bitumen used in pavement construction in Malaysia. There were no changes needed to the bitumen used in this investigation. Table 1 displays the specifications for the bitumen 60/70 that was used.

Table 1. The properties of bitumen grade 60/70

Test	Standard	Requirement
Penetration at 25°C, 0.1 mm	ASTM D5	60-70
Softening Point (°C)	ASTM D36	49-56

2.1.2 WEO

WEO was used as a modifier in an asphalt binder for this project. The WEO used is of semi-synthetic type and was collected from the motorcycle workshop, which is located near Gate 2 of the International Islamic University Malaysia (IIUM) Gombak campus. The choice of WEO was based on its hydrocarbon composition, which allows effective chemical interaction with bitumen components.

2.2 Sample Preparation

WEO was blended with bitumen and subsequently combined with aggregate and mineral filler to produce a dense-graded asphalt concrete (AC14) mixture. WEO is mixed with bitumen in a liquid state using a mixer at elevated temperature to evenly distribute the modifier and improve the blend's overall uniformity by making it easier for the WEO to be incorporated into the bitumen matrix. To create an asphalt mixture, it will be mixed with aggregate and filler. The aggregate gradation used for the asphalt mixture followed the AC14 specification as outlined in the Malaysian Public Works Department (JKR/SPJ/2008) standard. Table 2 displays the proportion of lower and upper bounds of the aggregate passing that was chosen within the Malaysia Public Works Department's Grading B specification (PWD, 2008). As illustrated in Figure 1, the gradation limit of the combined aggregate for the porous asphalt mixture was chosen in compliance with the Malaysia Public Works Department specification, PWD (2008).

Table 2. Open-graded range value for Grading B (PWD, 2008)

BS Sieve Size, mm	Percentage Passing, by weight	
	Grading A	Grading B
20.000	-	100
14.000	100	85 - 100
10.000	95 - 100	55 - 75
5.000	30 - 50	10 - 25
2.360	5 - 15	5 - 10
0.075	2 - 5	2 - 4

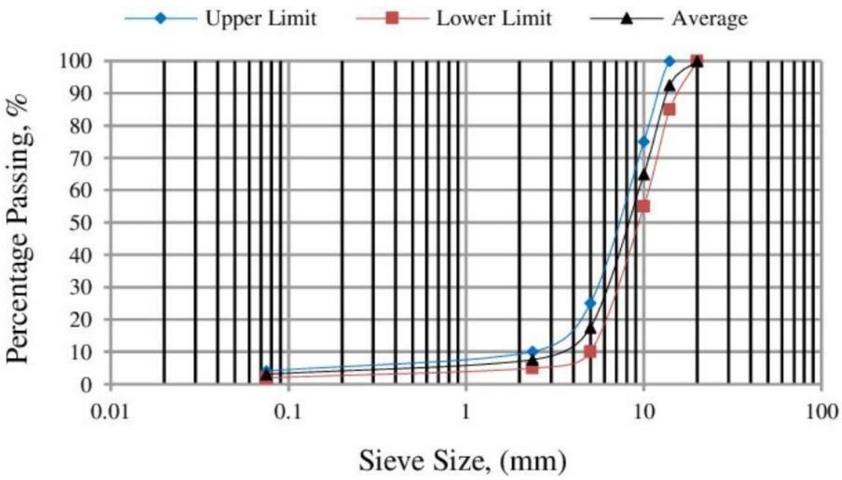

Figure 1. Gradation limits for porous asphalt mixtures (PWD, 2008)

2.2.1 The percentage of WEO replacement in bitumen

As seen in Table 3, the characteristics of modified bitumen are examined by adjusting the percentage of WEO incorporated into asphalt binders. Because of this, different proportions of WEO must be used in place of asphalt binders, beginning with modified and controlled bitumen that is 0.2%, 0.4%, 0.6%, and 0.8%. The range between 0 and 0.8% replacement of WEO yields the best results. A hot plate and mixer were used to prepare the modified binder with WEO. For one hour, the mixing process was conducted at 4000 rpm [11].

Table 3. Sample details

Mass of Bitumen 60/70 (g)	Bitumen 60/70 (%)	WEO replacement (%)	Mass of WEO (g)
550	100.0	0	0
550	99.8	0.2	1.1
550	99.6	0.4	2.2
550	99.4	0.6	3.3
550	99.2	0.8	4.4

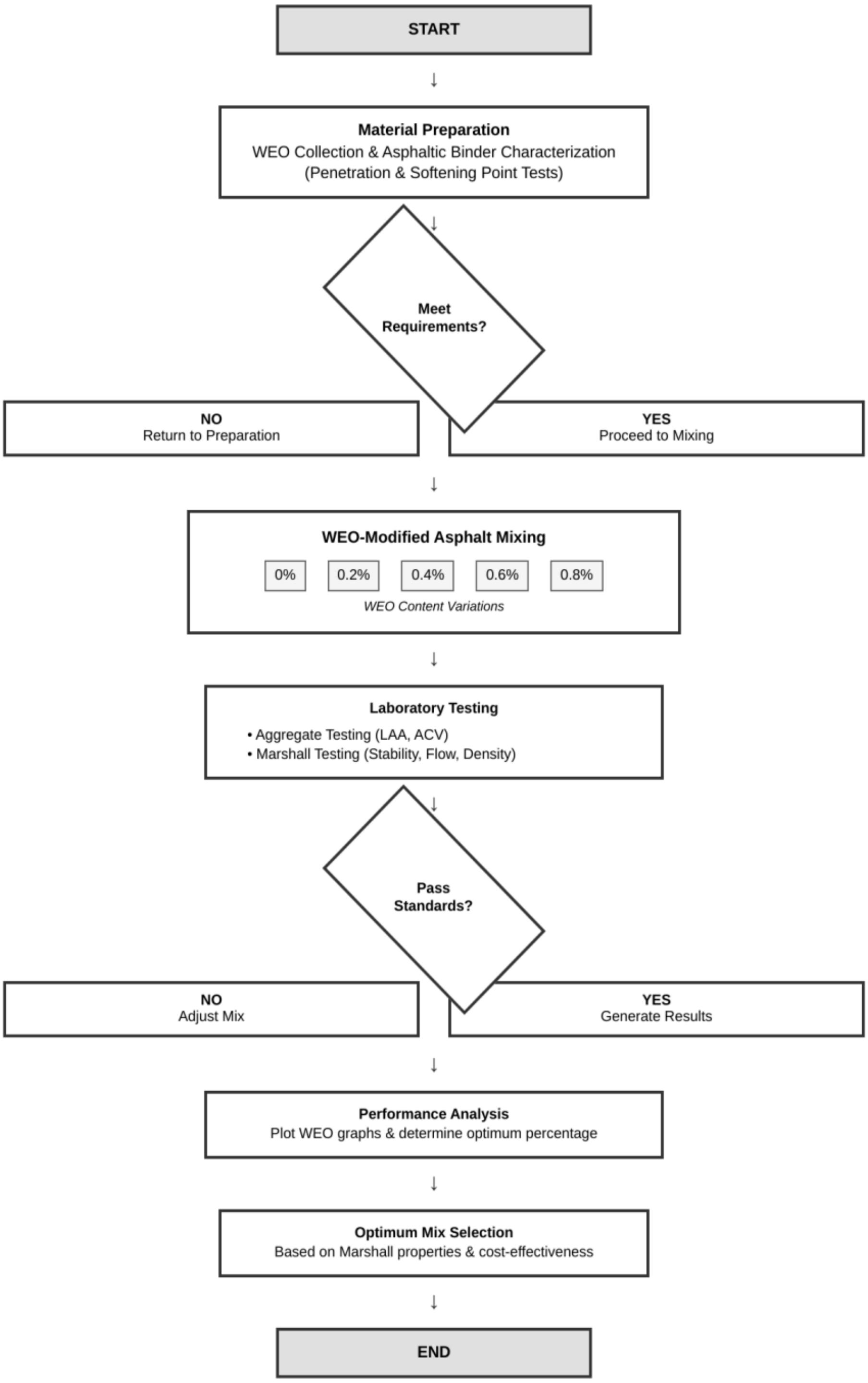

Figure 2. Asphalt mixture sample preparation methodology

2.3 The Experimental test

A range of laboratory tests were conducted to examine the properties of the aggregates, binder, and asphalt mixtures used in this research. The LAAV (Los Angeles Abrasion Value) test, based on ASTM C131, conducted laboratory abrasion tests on coarse aggregates to measure the aggregate's resistance to abrasion. A 5 kg sample of the coarse aggregate was passed through an abrasion machine for 500 revolutions. The Aggregate Crushing Value (ACV) test, based on ASTM C131-87 / BS812-110:1990, was carried out to assess the strength of the aggregates under compressive loads. Standard steel cylinders were employed with a compressive testing machine capable of applying at least 40 tonnes. The binder properties were determined using two standard tests. The Penetration test (ASTM D5 / BS2000: Part 49:1983) determined the binder's consistency at 25°C using a penetration needle and a water bath apparatus. The Softening Point (ASTM D36) was carried out using the ring-and-ball method to establish a temperature at which the bitumen would soften when determined by heat. The performance of the asphalt mixtures was evaluated using the Marshall Stability and Flow tests, according to ASTM D1559. Asphalt specimens were conditioned in a 60°C water bath, and the tests were conducted with a Utest Automatic Marshall Stability Machine. Stability was defined as the maximum load the specimen could take, and the same is true for flood which is the resulting deformation. All test data were recorded and analyzed showing a computer-generated output.

3. RESULTS AND DISCUSSION

This section provides the outcomes and findings from the experimental tests conducted at the Soil and Transportation Laboratory. A total of 10 asphalt samples were made with five different contents of WEO: 0%, 0.2%, 0.4%, 0.6%, and 0.8% by weight of bitumen, with 2 samples made for each percentage. Laboratory tests were performed to determine the performance characteristics of the asphalt mixtures. In particular, the Marshall Stability Test was used to examine the strength and durability of the modified and controlled mixtures. The physical characteristics of controlled/modified bitumen were also evaluated using the Penetration Test and the Softening Point Test. In addition to the asphalt samples, Los Angeles Abrasion Value and Aggregate Crushing Value tests were performed to examine the properties/functions of the aggregates. Overall, the complete laboratory data set can be used to determine the optimum WEO value that will improve the bitumen content and life of the asphalt mixture.

3.1 Los Angeles Abrasion Value Test (ASTM C131)

The goal of the study was to evaluate aggregate deterioration caused by rubbing against steel balls. The LAAV test investigated the degradation of coarse aggregate placed inside a rotating drum filled with steel spheres. Equation 1 yielded a Mean Los Angeles Abrasion Value (LAAV) of 32.6% for the aggregates used in this investigation, as shown in Figure 3. According to ASTM C131, both samples' mean LAAVs must be less than 40% to ensure acceptable resistance to wear and degradation under traffic loading. The test results, summarized in Table 4, show that both Test 1 and Test 2 yielded an LAAV of 32.6%, resulting in a mean value of 32.6%. This value falls within the designated range, indicating that the aggregates possess adequate resistance to abrasion.

Pavements requiring exceptional performance should use coarse aggregates with a lower abrasion value [12]. A lower LAAV denotes improved resistance to particle disintegration brought on by environmental influences and vehicle movement. Because of this, the aggregates are more resilient and less likely to break up into small pieces, which over time could otherwise weaken the structure of the asphalt. By extending the pavement's lifespan and minimizing surface imperfections like raveling and stripping, the use of aggregates with high abrasion resistance enhances long-term performance and lowers maintenance costs.

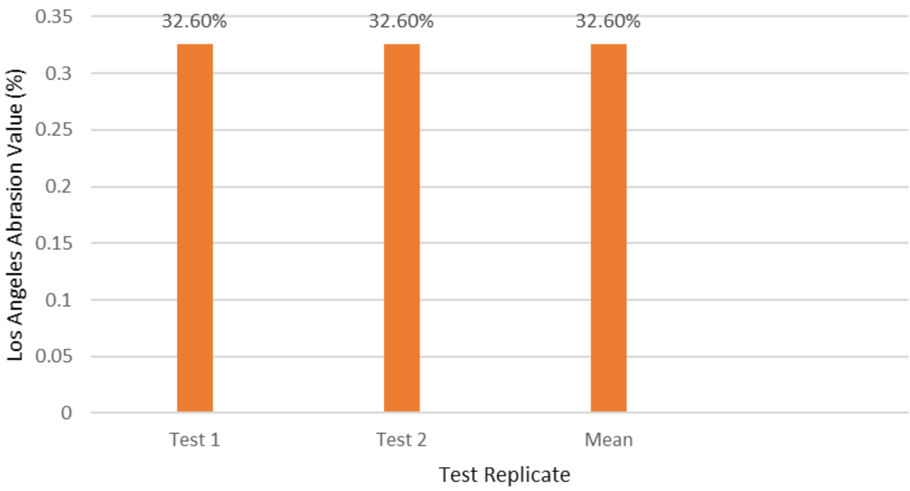

Figure 3: Los Angeles Abrasion Value (LAAV) test results

3.2 Aggregate Crushing Value Test (ASTM C131-87 / MS-30)

To determine the strength and toughness of road aggregate, the aggregate crushing test is essential [13]. Table 4 and Figure 4 presents the results obtained from two samples, both of which produced an ACV of 23.33%, with a mean value of 23.33%. which is less than 30% from the MS-30 standard, indicating that the aggregates possess good crushing resistance and are suitable for use in flexible pavements. Aggregates with low crushing values are more durable and less likely to fracture under traffic-induced stresses. By doing this, asphalt pavements' structural integrity is improved and the likelihood of long-term deformation like rutting is decreased. Consequently, the pavement's long-term stability, strength, and service life are enhanced by the use of such aggregates. It has been demonstrated that proper compaction is essential to preventing excessive aggregate breakage during construction when coarse aggregates with low crushing resistance are considered for use in asphalt mixtures [14]. Inadequate compaction can lead to particle degradation under load, which may compromise the interlocking structure of the aggregate matrix and reduce the overall strength and durability of the pavement.

Table 4. Results obtained from ACV test

Sample	Aggregate Size (mm)	Weight of crushed aggregate (g)		% Loss	Average % Loss
		Before (M1)	After (M2)		
A	14-10	5550	700	23.33	23.33
B	14-10	5550	700	23.33	

Note: ACV = (Weight of crushed aggregate passing 2.36mm sieve / Initial weight) × 100%

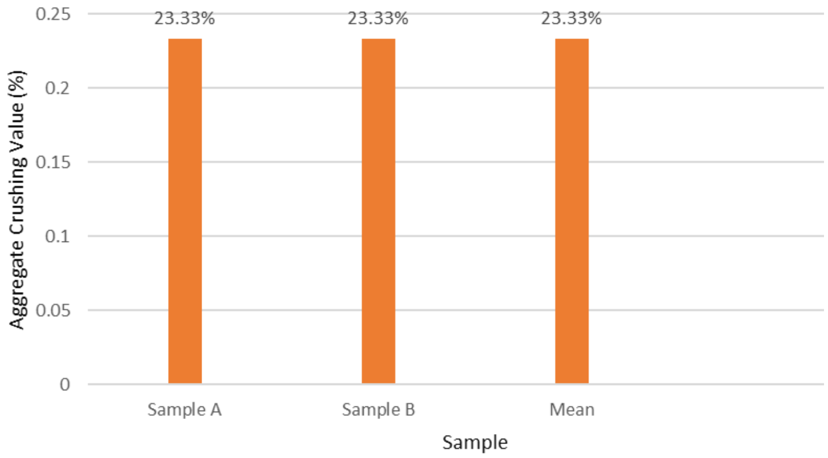

Figure 4. Aggregate Crushing Value (ACV) test results

3.3 PENETRATION TEST (ASTM D5)

Both modified and unmodified bitumen are evaluated for hardness or consistency using the penetration test. With a penetration value of 6.42 mm, the control bitumen which has 0% WEO shows the highest hardness without the addition of WEO, satisfying ASTM D5 requirements for PEN 60/70 grade. Penetration values of 6.49 mm, 6.55 mm, 7.06 mm, and 7.44 mm are observed in modified bitumen samples containing 0.2%, 0.4%, 0.6%, and 0.8% WEO, respectively. This data suggests that bitumen becomes softer when the bitumen's WEO content increases. The results from Table 6 indicate that bitumen softens more when WEO is incorporated, with the lowest penetration value being 6.42 mm at 0% WEO and the highest being 7.44 mm at 0.8% WEO.

Rutting is one of the main problems affecting flexible pavements, as it undermines the structural integrity and serviceability of roads [15]. Some of the causes of rutting are inadequate compaction, excess traffic loads, unsuitable mix design, and insufficient stiffness of bitumen. The bitumen modified with WEO is softer than regular bitumen which may affect its resistance to rutting. Generally, bitumen of good consistency or with low penetration is preferred, as the former may induce brittleness in low temperatures, the latter improves resistance to permanent deformation [16]. Figure 5 shows a graph of penetration (mm) with the percentage of WEO (%) replaced.

Table 6. Results obtained from penetration test

Sample	Trial	Mean
0%	6.50	6.42
	6.30	
	6.45	
0.2%	6.52	6.49
	6.41	
	6.54	
0.4%	6.67	6.55
	6.73	
	6.26	
0.6%	7.34	7.06
	7.01	
	6.82	
0.8%	7.46	7.44
	7.14	
	7.71	

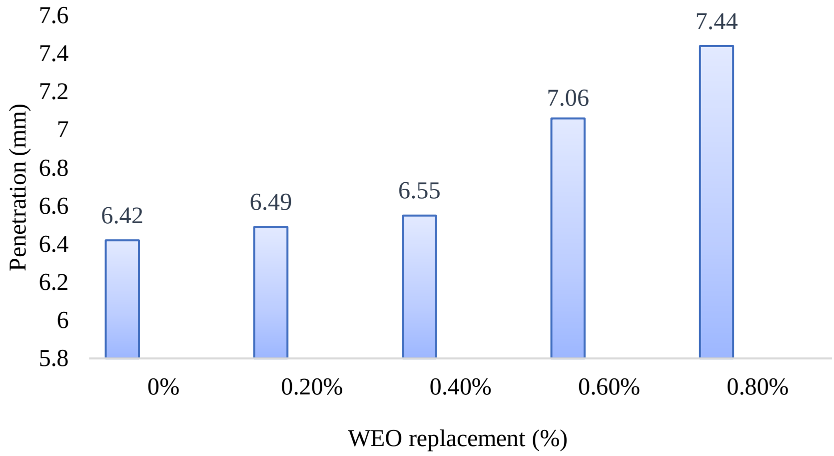

Figure 5. Penetration value (mm) against percentage of WEO replaced (%)

3.4 Softening Point Test (ASTM D36)

The temperature at which bitumen changes from a solid to a liquid state is ascertained using the softening test. Both modified and unmodified bitumen were examined in this investigation and the results is shown in Table 7. The unmodified bitumen, which was used as the control and contained 0% WEO, displayed a softening point of 49°C, falling between the 49°C and 56°C range for PEN 60/70 bitumen specified by ASTM D36. The softening points of modified bitumen samples containing 0.2%, 0.4%, 0.6%, and 0.8% WEO were 48.5°C, 45.0°C, 43°C, and 41.5°C, in that order. This suggests that a higher WEO content lowers the bitumen's softening point, reducing its resistance to temperature changes and speeding up the rate at which viscosity changes.

When the WEO percentage increases, the bitumen begins to soften and consequently allow for the liquefaction necessary for roadworks. A lower softening point does indicate the lower capability to endure higher temperatures and also a higher susceptibility to moisture, both of which can lead to road surface damage [17] [18] [19]. The softening point decreases linearly with WEO percentage from Figure 6.

Table 7. Results obtained from softening point test

Percentage replaced of WEO (%)	Ball 1 (ºC)	Ball 2 (ºC)	Mean (ºC)
0	49.0	49.0	49.0
0.2	48.0	49.0	48.5
0.4	45.0	45.0	45.0
0.6	43.0	43.0	43.0
0.8	41.0	42.0	41.5

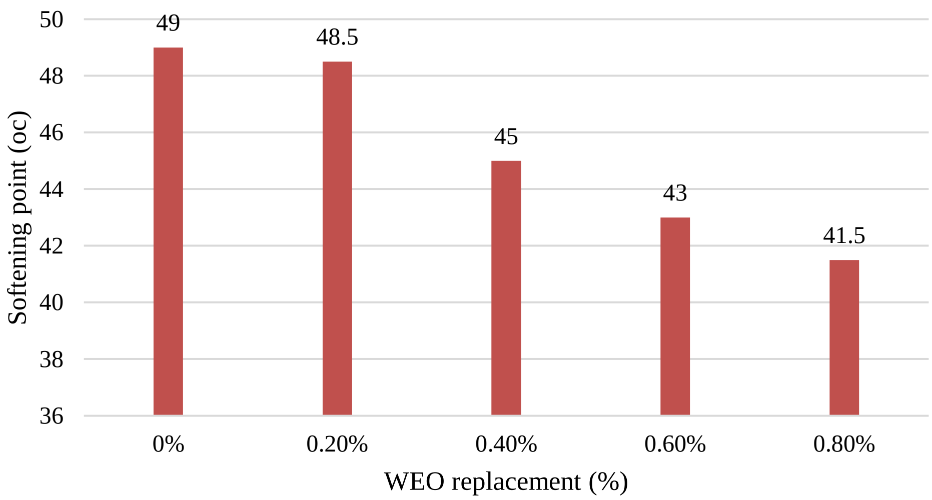

Figure 6. Softening point value (ºC) against percentage of WEO replaced (%)

3.5 Marshall Stability Test

The three tests that make up the Marshall Stability Test are flow, stiffness, and stability. The results of the Flow Test and Stability Test were obtained with the aid of a Marshall Compression Machine (30kN). The weight and height of the control, modified, and unmodified samples for the Marshall Stability Test are shown in Table 8.

Table 8. Weight and height of controlled and modified asphalt mixture sample for marshall stability test

Percentage of WEO (%)	Initial weight (kg)	Height (mm)
0	1.225	68.00
0.2	1.224	67.00
0.4	1.224	67.00
0.6	1.226	68.00
0.8	1.236	70.00

3.5.1 Stability Test

The goal of the Marshall Stability test was to ascertain how bitumen viscosity and aggregate friction affected the stability of asphalt mixtures using a 30 kN Marshall Compression machine. According to Figure 7, Marshall Stability results were 9.058 kN, 17.709 kN, 14.348 kN, 8.223 kN, and 8.170 kN at 0%, 0.2%, 0.4%, 0.6%, and 0.8% WEO content, respectively. At 8.170 kN, the sample containing 0.8% WEO demonstrated the least stability, whereas at 17.709 kN, the sample containing 0.2% WEO displayed the most stability.

According to Table 9, the stability of asphalt mixtures generally decreased with the addition of WEO. The reason may be the softening effect that WEO has on the bitumen, where it reduces the viscosity and stiffness of the asphalt mix, thereby decreasing the mixes hydrological resistance to strain. With the binder softened, the inter-molecular structure also becomes weaker, which makes the mix more susceptible to rutting from repetitively loaded traffic. Also, in [20], it was shown that higher WEO content reduced load carrying capacity. Likewise, [6] described elevated WEO content as softening bitumen and lowering the viscosity of the asphalt, which decreased the mechanical strength of the mix.

Table 9. Stability of controlled and modified asphalt mixture sample

Percentage of WEO (%)	Stability (kN)
0	9.058
0.2	17.709
0.4	14.348
0.6	8.223
0.8	8.170

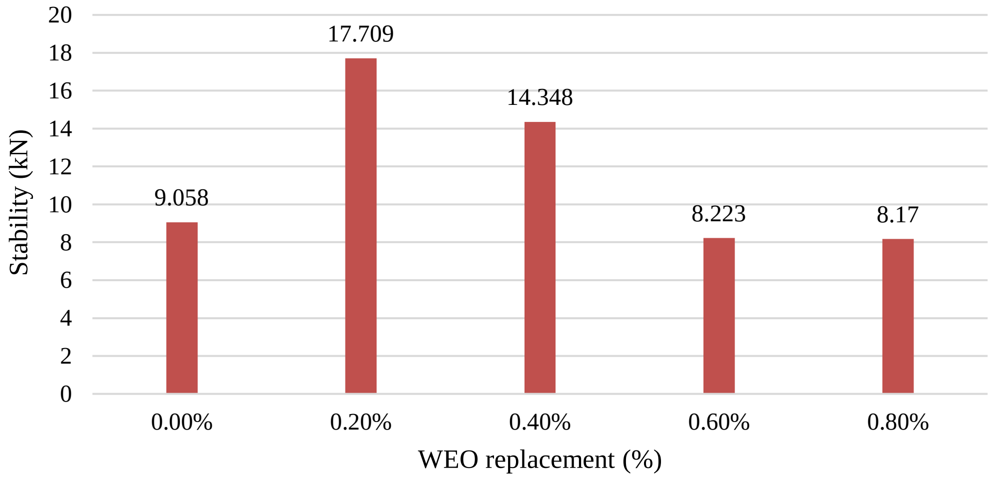

Figure 7. Stability (kN) vs percentage of WEO (%)

3.5.2 Flow Test

The data for the flow test, which gauges aggregate movement under vertical load, came from the Marshall Stability test, which used a 30 kN Marshall Compression machine. According to Table 10 and Figure 8, the flow values were

2.783mm, 3.097 mm, 3.220 mm, 3.834 mm, and 5.045 mm for 0%, 0.2%, 0.4%, 0.6%, and 0.8% WEO content, respectively. The 0.2% WEO mixture had the lowest flow value at 3.097 mm, while the mixture with 0.8% WEO showed the highest flow value of 5.045 mm, indicating greater aggregate movement and decreased stability. The findings demonstrate that, because of the additional ductile and flexible components that WEO introduces and which lessen internal friction between the aggregate particles and the asphalt bitumen, the flow value increases as WEO content increases. The oil weakens the binding between bitumen and aggregate [6], corroborate this finding. Greater flow values indicate increased susceptibility to movement under traffic load and temperature fluctuations, which makes them less desirable for use in road construction.

Table 10. Flow of controlled and modified asphalt mixture sample

Percentage of WEO (%)	Flow (mm)
0	2.783
0.2	3.097
0.4	3.220
0.6	3.834
0.8	5.045

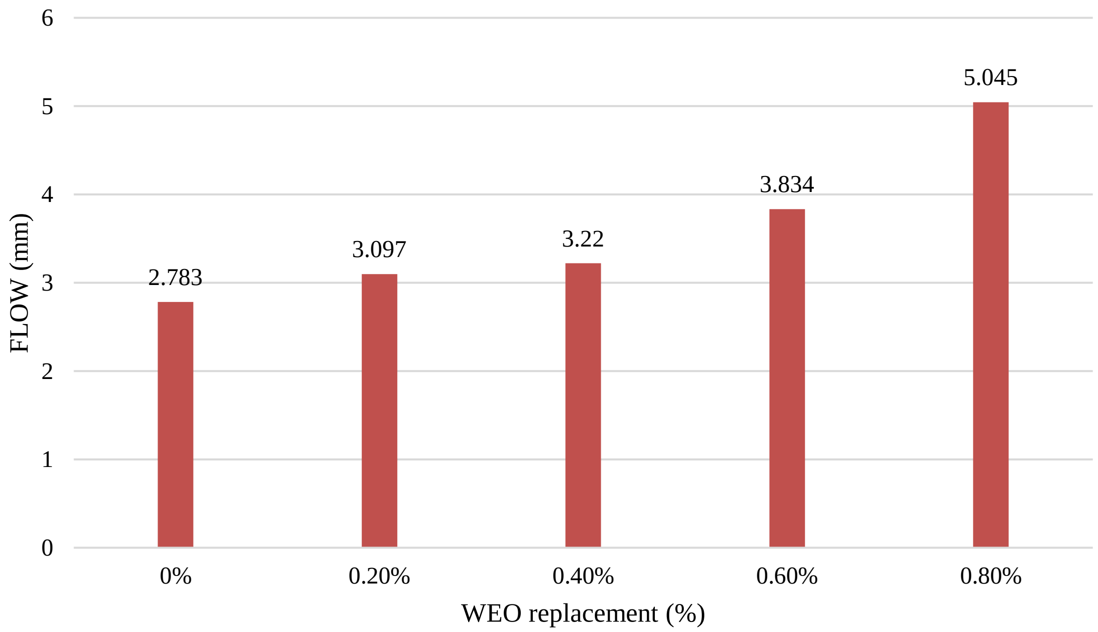

Figure 8. Flow (mm) vs percentage of WEO (%)

3.5.3 Stiffness Test

Equation 3 was used to assess and estimate the asphalt mixture's stiffness. According to the equation, an asphalt mixture's stability and flow both affect how stiff it is. As a result, the stiffness and stability value are directly proportional. Increased stiffness is indicative of a more stable composition of asphalt.

$$Stiffness = \frac{Stability}{Flow} \tag{3}$$

Measurements of the stiffness values of asphalt mixtures with different WEO contents showed that the stiffness decreased significantly with increasing WEO content. The stiffness values based on Table 11 and Figure 9 were 10.65 kg/mm, 5.718 kg/mm, 4.456 kg/mm, 2.145 kg/mm, and 1.619 kg/mm for mixtures with 0%, 0.2%, 0.4%, 0.6%, and 0.8% WEO content, respectively. Higher WEO content decreases mixture stiffness because of higher flow and lower stability; the highest stiffness was seen at 0% WEO and the lowest at 0.8% WEO [6].

Elevated stiffness in asphalt mixtures reflects a stronger resistance to deformation, improved load-bearing capacity, and reduced creep under prolonged loading and high temperatures. This means the pavement can better maintain its shape and structural integrity over time, especially under heavy traffic. However, when stiffness becomes excessive, the mixture loses its flexibility, increasing the risk of fatigue cracking due to repeated stress and temperature variations. Such cracks can compromise pavement durability and lead to costly maintenance. Therefore, as emphasized in [21], achieving an optimal balance in stiffness is crucial to ensure long-term performance and durability of asphalt pavements.

Table 11. Stiffness of controlled and modified asphalt mixture sample

Percentage of WEO (%)	Stiffness (kg/mm)
0	3.255
0.2	5.718
0.4	4.456
0.6	2.145
0.8	1.619

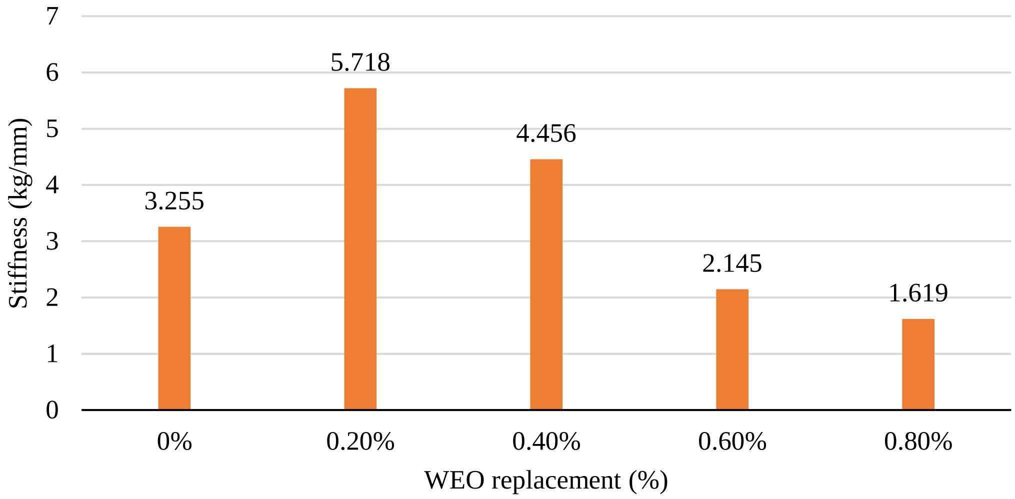

Figure 9. Stiffness (kN/mm) vs percentage of WEO (%)

4. CONCLUSIONS

This study showed that adding WEO to bitumen changes the engineering properties of asphalt mixtures. The assessment of binder properties indicated that as the WEO content increased from 0% to 0.8%, the penetration values rose from 6.42 mm to 7.44 mm. This change points to softer binder. At the same time, softening points dropped from 49°C to 41.5°C, confirming that WEO softens the bitumen. For Marshall Stability, the control mix with 0% WEO had low stability at 9.058 kN. The highest stability, recorded at 0.2% WEO replacement, was 17.71 kN, along with an acceptable flow value of 3.1 mm, marking this as the best dosage. However, increasing the WEO content further led to lower stability, suggesting that too much WEO weakens structural performance. The analysis of flow and stiffness supported this finding. The 0.2% WEO mixture achieved an optimal stiffness value of 5.718 kN/mm. In contrast, higher WEO levels caused excessive deformation (flow) and greatly decreased stiffness, harming the mechanical strength of the asphalt mixture. Based on the results, 0.2% WEO by weight of bitumen is recommended as the best replacement level. It strikes a good balance of improved mechanical performance and durability while positively impacting environmental sustainability through waste reuse. This amount boosts pavement quality and supports green construction efforts.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHORS CONTRIBUTION

Wan Nur Aifa Wan Azahar, Muhammad Amirul Hakim Azman: Research idea, analysis of results, collection of results, experimentation, writing original draft

Norhidayu Kasim, Nur Khairiyah Basri, Ahmad Bukhari Ramli: Supervision

Nur Atikah Kamaruzaman: Draft Conception and Design

AVAILABILITY OF DATA AND MATERIALS

The data and materials used to support the findings of this study are included within the article.

ETHICS STATEMENT

Not applicable.

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