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Evaluating Bitumen Extraction Efficiency & Accuracy among Two Mix Types

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Abstract

Determining the binder content in hot mix asphalt (HMA) is essential for ensuring pavement quality and performance. This study compares two methods Ignition Furnace and Centrifuge Extraction to assess bitumen content in HMA mixtures and examine the impact of both methods on aggregate integrity. Two mix types, Asphalt Concrete Base course ACB 28 and Stone Mastic Asphalt SMA 14, were designed using the Marshall mix design system in accordance to AASHTO standards. The optimum bitumen content for each mix was determined to be 4.8% and 6.1%, respectively. However, sieve analysis revealed observable changes in some sieves of SMA14. Findings indicate variability in SMA14 between ignition and centrifuge methods however, statistical analysis does not confirm a significant difference. In contrast, ACB28 exhibits a t-statistic surpassing the critical limit, indicating statistical significant in the result. The p-value is close to the conventional cutoff for significance, suggesting ACB28 likely exhibits a real effect but remains on the boundary of statistical confidence.

Keywords: HMA, binder content, SMA14, ACB28, centrifuge solvent extraction, ignition method

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تقييم كفاءة ودقة استخلاص البيتومين بين خلطتين

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الملخـــــــص

تحديد محتوى البيتومين في الخلطة الإسفلتية الساخنة يعد أمر أساسيا لضمان جودة وأداء الرصف. تقارن هذه الدراسة بين طريقتين الفرن الحراري والاستخلاص بالطرد المركزي لتقييم محتوى البيتومين في خلطات الإسفلت الساخنة وفحص تأثير كلتا الطريقتين على سلامة الركام. تم تصميم نوعين من الخلطات باستخدام نظام تصميم مارشال SMA14 ACB28 بمحتوي اسفلتي (4.8% 6.1%) لكل خلطة على التوالي. وقد أظهر التحليل المنخلي للركام تغييرات ملحوظة في التدرج نتيجة لتأثير درجة الحرارة المرتفعة والمذيبات أدى الى تباين في بعض المناخل في SMA14. من ناحية اخري يظهر التحليل الاحصائي للخلطة ACB28 قيمة تتجاوز العتبة الحرجة بينما تقترب قيمة P– value من الحد التقليدي للدالة الإحصائية مما يشير الى انها تقع على حدود الثقة الإحصائية.

الكلمات المفتاحية: محتوى البيتومين، الخلطة الإسفلتية الساخنة، الفرن الحراري، الاستخلاص بالطرد المركزي.

1.0 INTRODUCTION:

Asphalt has been used for millennia, with bitumen acting as a vital binder in hot mix asphalt. Its content directly affects pavement durability excess leads to stability issues, while insufficient amounts weaken longevity (Brian D. Prowell 2002)".

Ignition testing, developed by NCAT, determines asphalt content in HMA mixtures without solvents. It uses a furnace meeting AASHTO T308 and ASTM D6307 standards, calculating bitumen content from mass loss after ignition (Vikash Kumar Aravind ,2014)". The centrifuge extraction method efficiently determines bitumen content in paving mixtures. Following AASHTO T58, T164 standards, it involves heating, cooling, and solvent extraction. TCA and TCE were historically used as solvents (Stroup Gardiner

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Nelson, 2000)". In addition, research indicates that ignition testing closely aligns with centrifuge extraction when ammonium carbonate is omitted. This suggests it may overcompensate for minerals unaffected by ignition, warranting further evaluation (J. Neves 2019)".On the other hand testing 80 HMA samples with limestone and gravel aggregates confirmed that aggregate type, gradation, and bitumen content impact measurement accuracy, influencing deviations between true and measured binder content (Ahmed Magdy Eslam,2021)".

Research on RAP and virgin binder highlights that assuming full blending can reduce binder content and pavement durability. A modified blending chart and partial blending method help optimize binder grade and content, improving cracking resistance while preserving rutting performance (Shuai, Ping Shihui 2021)".

1.1 Problem Statement

Bitumen extraction methods play a crucial role in assessing the binder content of asphalt mixtures, directly impacting pavement performance and durability. However, variations in efficiency and accuracy among different extraction techniques can lead to discrepancies in measured binder content. This study aims to evaluate and compare the effectiveness of ignition and centrifuge extraction methods across two different mix types

1.2 OBJECTIVE

This research analyzes the influence of mix type and investigates how aggregate and mix characteristics affect extraction precision.

2.0 METHODOLOGY:

A test plan was developed to achieve the study's objectives. The Marshall mix designs were adopted from two previous studies based on AASHTO standards, resulting in the production of stone mastic asphalt SMA14 and asphalt concrete base course ACB28 mixture types. The optimum bitumen content for each mix was determined to be 6.1% and 4.8%, respectively. Six specimens were prepared for each mix, with three specimens each tested using the Centrifuge Extraction Method (AASHTO T164) and three using the Ignition Furnace Method (AASHTO T308) [7][8].

2.1 calculation:

Calculate the asphalt content by centrifuge extraction.

$$\text{Asphalt Content \%} = \frac{w1-(w2+w3)}{w1} \times 100$$

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Where:
W1 = weight of test sample, g
W2 = weight of extracted aggregate, g
W3 = weight of fines in extracted solvent, g

Calculate the asphalt content by ignition furnace.

$$\text{Asphalt Content \%} = \frac{Mi - Mf}{Mi} \times 100 - Mf - Cf$$

Where:
Pb = the corrected asphalt binder content as a percent by mass of the HMA sample

Mf = the final mass of aggregate remaining after ignition
Mi = the initial mass of the HMA sample prior to ignition
Cf = Asphalt binder correction factor as percent by mass of the HMA sample
M = percent moisture content.

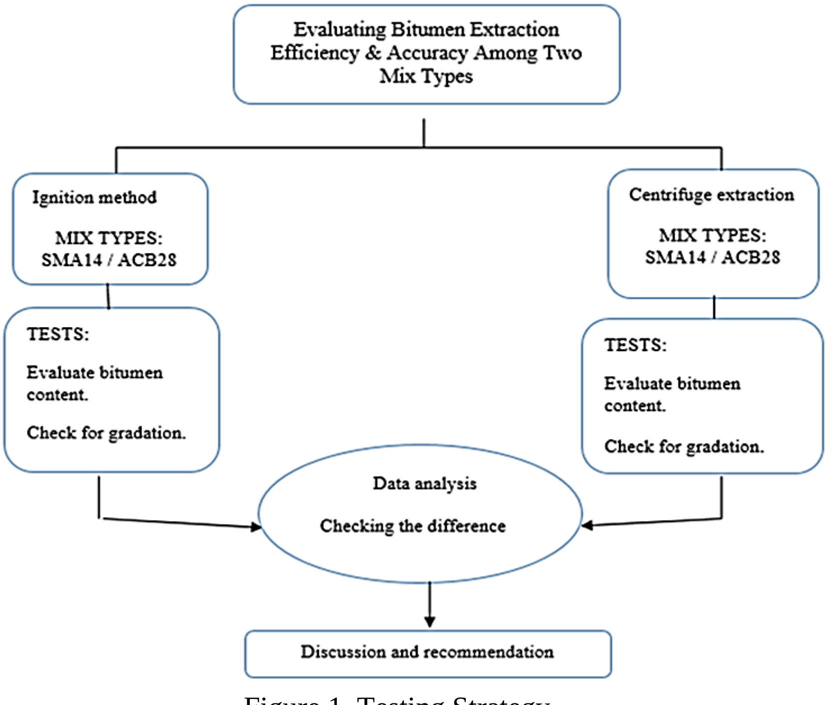

Figure.1. Testing Strategy

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Results and Discussion:3.0

3.1 Ignition and centrifuge Aggregate gradation:

Gradation analysis of SMA14 and ACB28 using centrifuge and ignition extraction revealed significant deviations, especially in SMA14, where all sieves showed bias ranging from -3.38 to 8.2. These shifts highlight the impact of extraction techniques, While SMA14 exhibited major gradation variations, ACB28 remained relatively stable. The tables below show the difference among the two methods.

Table 1. Illustrates the gradation of SMA14 Ignition & centrifuge

Sieve Size mm	lower	upper	True% passing	Avg passing % Igni	Bias % Igni	Avg passing % Cent	Bias % Cent
12.5 mm	100	100	100	100	0	100	0
9.5 mm	72	83	77.5	85.62	8.12	85.70	8.20
4.75 mm	25	38	31.5	32.32	0.82	31.11	-0.38
2.36 mm	16	24	20	23.81	3.81	22.61	2.61
600 um	12	16	14	12.65	-1.34	12.22	-1.77
300 um	12	15	13.5	11.69	-1.80	11.34	-2.15
75 um	8	10	9	6.08	-2.91	5.61	-3.38

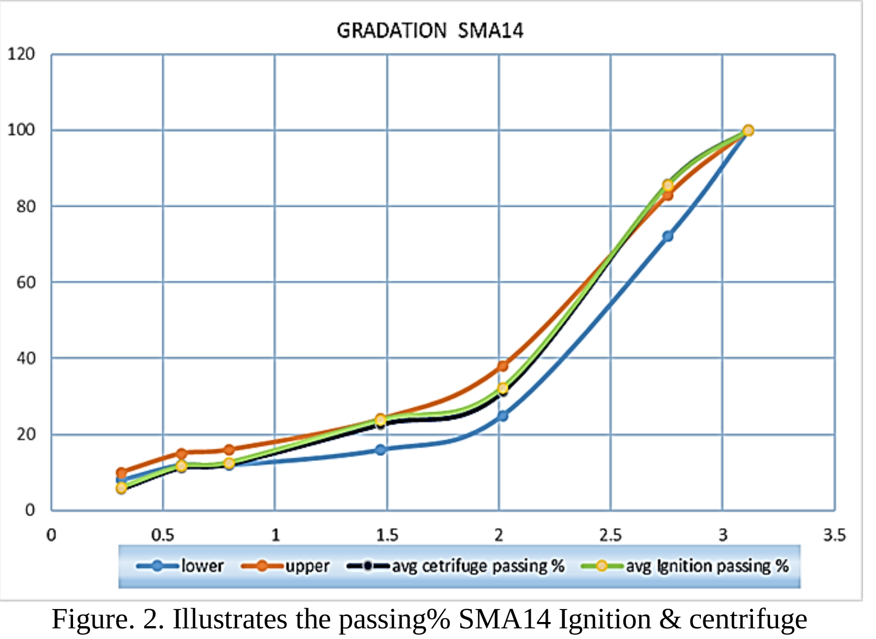

Figure. 2. Illustrates the passing% SMA14 Ignition & centrifuge

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Table 2 illustrates the gradation of ACB28 Ignition & centrifuge

Sieve Size mm	low	upper	True% passing	Avg passing % Igni	Bias % Igni	Avg passing % Cent	Bias % Cent
28.0 mm	100	100	100	100	0	100	0
20.0 mm	72	90	85	82.45	-2.54	81.63	-3.36
14.0 mm	58	76	70	66.76	-3.23	67.14	-2.85
10.0 mm	48	64	56	55.84	-0.15	55.94	-0.05
5.0 mm	30	46	36	37.53	1.53	37.05	1.05
3.35 mm	24	40	28	31.72	3.72	31.21	3.21
1.18 mm	14	28	17	21.12	4.12	20.46	3.46
425 um	8	20	10	13.29	3.29	13.17	3.17
150 um	4	10	5	6.13	1.13	5.96	0.96
75 um	3	7	4	3.25	-0.74	3.11	-0.88

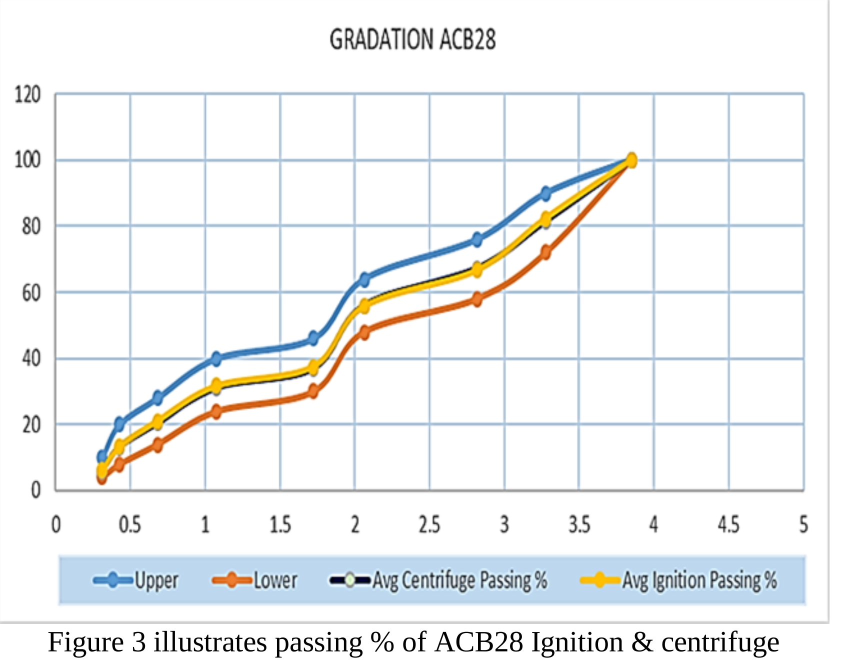

Figure 3 illustrates passing % of ACB28 Ignition & centrifuge

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3.2 Centrifuge & Ignition Binder Content:

Considering the average bitumen content (AC%) alongside the centrifuge and ignition results, we can refine the interpretation of statistical significance and performance differences between SMA14 and ABC28. The average ignition AC% (6.38%) is notably higher than the centrifuge AC% (5.96%), indicating potential binder loss in the centrifugal process. SMA14's t-statistic (3.589) falls below the critical threshold (4.302), suggesting no statistically significant effect. The high p-value (0.61791) further confirms the likelihood of random variation, supporting the null hypothesis. ABC28, on the other hand, demonstrates a t-statistic (4.625) exceeding the critical threshold (4.302), making the results statistically significant. The p-value (0.05083) is close to the conventional cutoff for significance (0.05), meaning ABC28 likely exhibits a real effect but sits on the boundary of statistical confidence as shown in table (3.3) (3.4).

Table 3 displays the Average AC% Ignition and Centrifuge

Mix	*AC%*	*Ignition AC%*	*Centrifuge AC%*
SMA14	6.1%	6.55	5.91
		6.3	6.05
		6.3	5.94
Avg		6.38	5.96
ACB28	4.8%	5.15	4.79
		5.15	4.94
		5.07	4.90
Avg		5.12	4.87

Table 4 displays the result of t-test Paired Two Sample

Mix	t stat	t critical two tail	P(T<=t) two-tail
SMA14	3.589	4.302	0.61791
ABC28	4.625	4.302	0.05083

4. Conclusion:

The study highlights the impact of extraction methods on bitumen content accuracy and aggregate gradation. SMA14 shows noticeable variability between ignition and centrifuge methods, with an average ignition AC% of 6.38% compared to 5.96% for centrifuge,

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suggesting binder loss sensitivity. However, statistical analysis indicates that this difference is not significant, meaning it may be influenced by random factors rather than a true effect. In contrast, ABC28 presents minimal variation, with ignition AC % at 5.12% and centrifuge AC% at 4.87%, showing borderline statistical significance in binder retention differences.

Beyond binder loss, SMA14's gap-graded aggregate structure plays a role in its susceptibility to extraction method variations. The observed shifts across sieves suggest that finer particles may be more affected during centrifuge extraction, leading to gradation inconsistencies. The bias range (-3.38 to 8.2) emphasizes the necessity for refined extraction techniques to ensure accurate assessments in SMA mixtures. Meanwhile, ABC28 remains more stable, reinforcing the idea that certain mix designs are less influenced by extraction-induced changes.

Ultimately, the findings underscore the importance of selecting optimized extraction methods for SMA mixtures to maintain mix integrity, enhance durability, and achieve reliable asphalt evaluations. Future studies should focus on improving methodologies to reduce binder measurement discrepancies while ensuring precise gradation assessments for long-term performance.

REFERENCES:

Ahmed Hemida. Magdy Abdelrahman. Eslam Deef-Allah 2021. Quantitative evaluation of asphalt binder extraction from hot mix asphalt pavement using ashing and centrifuge methods. Science Direct Transportation Engineering volume 3.

Brian D. Prowell. (2002) Evaluation of infrared furnace for determination of asphalt content. National Center for Asphalt Technology Auburn University, Alabama. NCAT Report 02-05.

J. Neves 2019. Comparison of Binder Content Determination by Centrifuge Extractor and Ignition Test Methods for HMA. International Airfield and Highway Pavements Conference.

Lab Manual, (2008). Asphalt Content of Hot Mix Asphalt, by Extraction Method. AASHTO Designation T164 Test Method A (MN/DOT Modified).

Lab Manual, (2024). Determining the Asphalt Binder Content of Asphalt Mixture by the Ignition Method. AASHTO T308.

http://www.doi.org/10.62341/esse0527

M. Stroup-Gardiner J.W. Nelson 2000. Use of normal propy bromide solvents for extraction and recovery of asphalt cements. Auburn University, Alabama. NCAT Report 00-06.

Shuai Yu, Ping Li, Zhidong Zhang and Shihui Shen 2021. Virgin Binder Determination for High RAP Content Mixture Design. Journal of Materials in Civil Engineering June Volume 33 Issue 6.

Vikash Kumar and Aravind Krishna Swamy 2014. COMPARISON OF TESTING MEHODS FOR DETERMINATION OF ASPHALT CONTENT FOR HIGH LOSS AGGREGATES. Colloquium on Transportation Systems Engineering and Management CTR, CED, NIT Calicut, India, May 12-13.