iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** XII **Month of publication:** December 2023

DOI: https://doi.org/10.22214/ijraset.2023.57033

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XII Dec 2023- Available at www.ijraset.com

Rejuvenating Aged Asphalt Binder from Reclaimed Asphalt Pavement through the Utilization of Waste Cooking Oil

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Abstract: ***This study investigates the use of waste cooking oil to rejuvenate aged asphalt binder from reclaimed asphalt pavement (RAP) in Peshawar, aligning with National Highway Authority (NHA) standards. Aged binder from RAP near Zintara Residence on Peshawar's Ring Road was combined with filtered cooking oil from local restaurants in varying proportions (1% to 5%). The rejuvenated binders underwent extensive physical and rheological tests, showing that certain fractions of cooking oil effectively revitalized the old binder, aligning it with virgin bitumen qualities. Superpave experiments on RAP mixes (30%, 40%, 50%) demonstrated comparable performance to fresh asphalt, particularly at 30% to 40% replacement levels. The results suggest that revitalized RAP holds promise as a sustainable alternative, enhancing asphalt mixes for road construction.***
Keywords: Waste Cooking Oil, Reclaimed Asphalt Pavement, Sustainable

I. INTRODUCTION

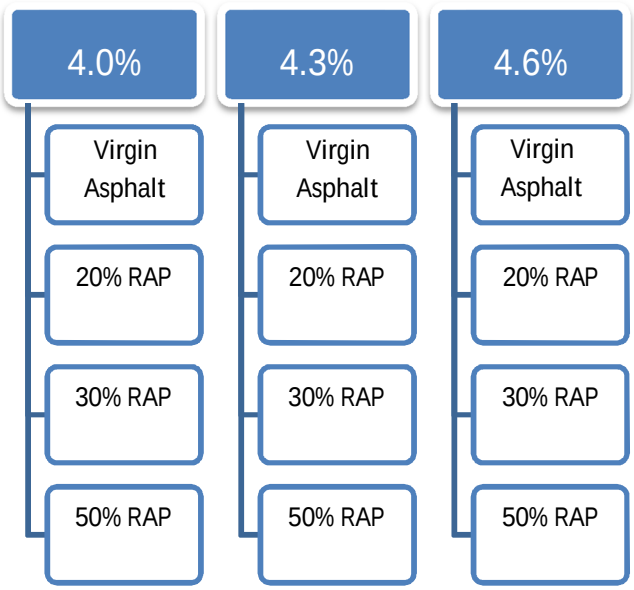
This study addresses the deterioration of asphalt pavements in Peshawar, Pakistan, exacerbated by diverse climate conditions. Aging asphalt binders from reclaimed asphalt pavement (RAP) contribute to decreased pavement durability. Following National Highway Authority (NHA) guidelines, the study explores the use of leftover cooking oil as a rejuvenating agent for aged asphalt binders. The research aims to improve pavement performance while addressing the environmental challenge of used cooking oil disposal. Through extensive experimentation aligned with NHA standards, the study anticipates providing valuable insights into enhancing the engineering qualities of aging asphalt binders in Peshawar's distinct climate, supporting sustainable infrastructure development goals.

A. Experimental Investigation

In this study, the experimental task involved the preparation of a total of 36 Marshall samples. Three distinct bitumen contents (4.0%, 4.3%, and 4.6%) and a 3% Waste Cooking Oil (WCO) were chosen for investigation. Each Marshall sample necessitates a total of 1250 grams of aggregates, WCO, and bitumen, with the WCO quantity set at 3%. The specific details for the remaining aggregates are as follows:

Table 1: Details of Percentages of Aggregates Used

BY PERCENTAGE OF TOTAL AGGREGATES	
Size	Percentage usage
10-20mm	38
5-10mm	34
Crushed stone	25
WCO	3



The initial samples were created using the Virgin Binder. Subsequent samples were produced by substituting the Virgin Binder with Modified Binder, and all samples underwent testing using the Marshall Stability Tester. To ensure accuracy, three samples were prepared for each condition, and the average of the test results was calculated according to code specifications. In total, 12 samples were generated for each bitumen content, distributed as follows: 12 samples for 4.0% bitumen, 12 for 4.3% bitumen, and 12 for 4.6% bitumen. The methodology is outlined as follows:

B. Experimental Results

The Marshall Stability Test results are presented in tables and accompanied by graphical plots. All values represent the averages derived from the three samples in each case.

Table 2: Details of Percentages of Aggregates Used

VIRGIN ASPHALT		
3% WCO		
BitumenContent	Marshall Stability(KN)	Flow (Unit)
4%	10.58	9.18
4.3%	11.71	10.62
4.6%	10.22	11.76
30% RAP REPLACEMENT		
3% WCO		
BitumenContent	Marshall Stability(KN)	Flow (Unit)
4%	12.28	10.22
4.3%	13.99	11.79
4.6%	13.16	12.71

40% RAP REPLACEMENT		
3% WCO		
BitumenContent	Marshall Stability(KN)	Flow (Unit)
4%	13.81	11.87
4.3%	15.70	12.67
4.6%	14.32	13.90
50% RAP REPLACEMENT		
3% WCO		
BitumenContent	Marshall Stability(KN)	Flow (Unit)
4%	11.10	16.07
4.3%	12.28	17.78
4.6%	10.99	18.65

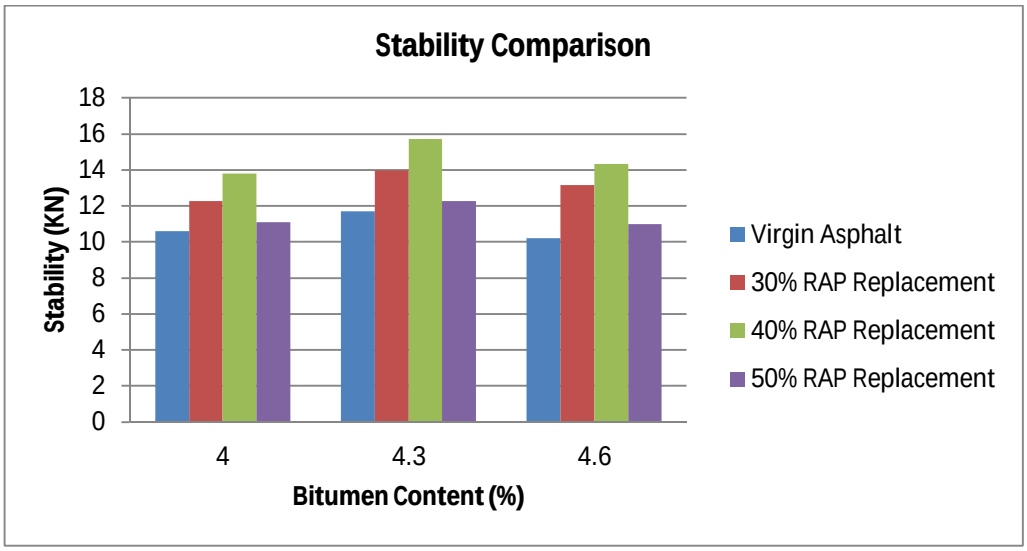


Figure 1: Comparison of Marshall Stability for Various RAP Mixes at Different Bitumen Contents

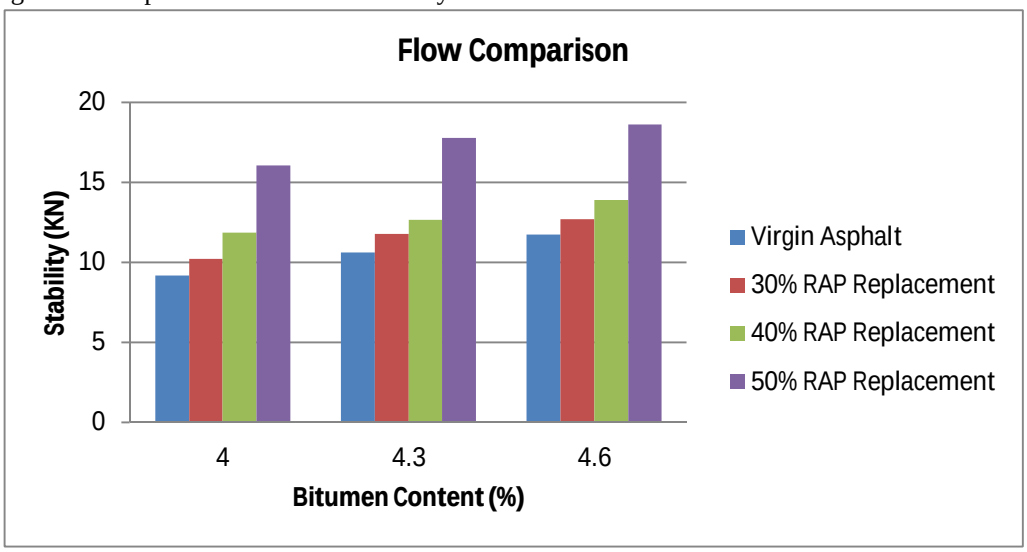


Figure 2: Marshall Flow of Various RAP Mixes at Different Bitumen Contents

II. CONCLUSION

The results distinctly indicate an enhancement in the Marshall stability of Waste Cooking Oil (WCO) modified samples compared to conventional asphalt. Notably, at a 40% Rejuvenated Reclaimed Asphalt Pavement (RAP) replacement, the stability reached its maximum across all bitumen content percentages. However, it is noteworthy that the flow of the modified samples increased, particularly at the 50% RAP replacement. Despite this increased flow, the stability of WCO modified samples demonstrates favorable outcomes.

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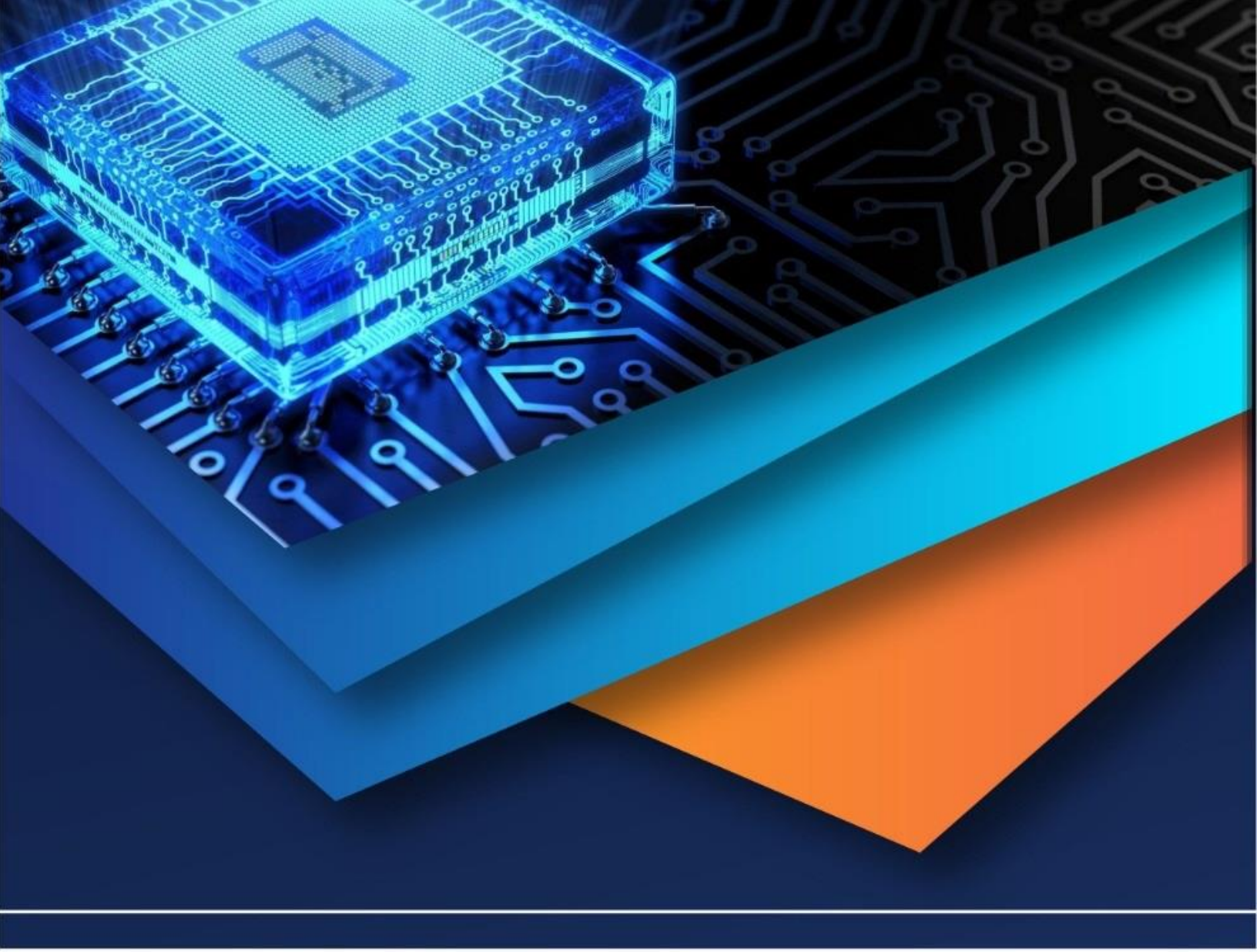

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