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Moisture Susceptibility of Aged Bitumen and Investigation on Potential Benefits of Different Fillers

Rosmy Philip[1], Anjitha Ajith[2],
Ruby BK[3],Thomas Mathew[4]
[1,2,3,4]UG Students, Department of Civil Engineering,
St Joseph's College of Engineering, Palai, Kerala.

Mr. Thomaskutty Mathew[5],
[5]Assistant Professor, Department of Civil Engineering,
St. Joseph's College of Engineering,
Palai, Kerala.

Abstract— **Bitumen and the Potential benefits of incorporating Eggshell powder and Cement powder as fillers in asphalt mixtures. The research involves laboratory experiments to evaluate the physical and Marshall properties of the bitumen, including penetration, softening point, ductility, viscosity, Marshall stability value. The moisture susceptibility of the bitumen is investigated by conducting the Retained Marshall test on asphalt specimens both in unaged and aged bituminous concrete mixes. The results indicates that aged bitumen exhibits higher moisture susceptibility compared to unaged bitumen, with a significant decrease in Marshall stability values for both VG30 and NRMB 70 grade bitumen. Additionally, VG30 grade bitumen shows higher moisture susceptibility than NRMB 70 grade bitumen. The findings suggest that the aging of bitumen has a considerable impact on its moisture susceptibility and that the grade of bitumen can also affect its resistance to moisture damage. The use of alternative materials as fillers has gained attention in recent years due to their potential to enhance the performance and sustainability of asphalt pavements. The experiment involves a series of laboratory tests to assess the effects of eggshell powder and cement powder on key properties of asphalt mixtures. The study evaluates the impact of these fillers on various performance parameters, including Marshall stability, flow, volumetric properties, and moisture susceptibility of the asphalt mixtures. The laboratory testing involves preparing asphalt mixtures with fillers exchanged and conducting mechanical tests following established standards. The results are compared with control samples containing only conventional fillers to assess the influence of the alternative fillers on the mixture's properties.**

Index Terms – **Moisture Susceptibility, Ageing of Bitumen, Fillers, Marshal stability value, Volumetric properties**

1. INTRODUCTION

Susceptibility to moisture damage is one of the major concerns in bituminous pavements. Moisture susceptibility is normally associated to the loss of adhesion between asphalt binder and aggregate and or loss of cohesion within the binder mainly due to the presence of water. Therefore, understanding the moisture susceptibility of bitumen and finding effective methods to mitigate it is of utmost importance for ensuring long-lasting and sustainable road infrastructure.

This study aims to investigate the moisture susceptibility of aged bitumen and explore the potential benefits of incorporating eggshell powder and cement powder as fillers in bituminous asphalt mixes. Fillers play a crucial role in enhancing the properties of asphalt mixes, including moisture resistance, stiffness, and durability. By utilizing waste materials such as eggshell powder and cement powder as fillers, this research seeks to not only improve the performance of bituminous asphalt but also contribute to sustainable waste management practices.

The choice of eggshell powder and cement powder as potential fillers is based on their inherent properties. Eggshell powder, derived from the discarded eggshells, possesses characteristics such as high calcium content, porosity, and fineness that may positively influence the moisture susceptibility of bituminous mixtures. Cement powder, a by-product of cement production or demolition waste, is known for its pozzolanic properties that enhance the binding and moisture resistance capabilities of bituminous mixes.

To accomplish the objectives of this study, a comprehensive experimental program will be conducted. Two bitumen grades (VG30 and NRMB) commonly used in Kerala for pavement construction are selected and their property tests, Marshall stability values are determined for both unaged and aged bituminous mix. Subsequently, different bituminous asphalt mixtures will be prepared by replacing conventional stone powder fillers with eggshell powder and cement powder. The moisture susceptibilityof these mixtures will be assessed in both unaged and aged bituminous mix using Retained Marshall stability test.

The findings of this study are expected to provide valuable insights into the moisture susceptibility of aged bitumen and the potential benefits of incorporating eggshell powder and cement powder as fillers in bituminous asphalt mixes. Overall, this study represents a significant step towards understanding the complex interplay between bitumen aging, moisture susceptibility, and the incorporation of innovative fillers, paving the way for more resilient and sustainable road construction practices.

2. AIM AND OBJECTIVES OF THE STUDY

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International Journal of Engineering Research & Technology (IJERT)
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1. Determine Marshal stability and volumetric properties of both unaged and aged bituminous mixes.
2. To Determine moisture susceptibility of both unaged and aged bituminous concrete mixes
3. To investigate the effects of using eggshell powder and cement powder as filler, on the properties of bituminous concrete mix.
4. To Conclude best Bitumen grade for the tropical climate of Kerala from the tests results

3. METHODOLOGY

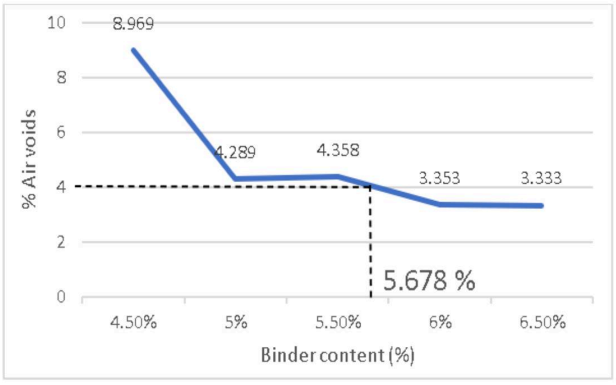
Two bitumen grades (VG30 and NRMB) commonly used in Kerala for pavement construction are selected and their property tests, Marshall stability values are determined for both unaged and aged bituminous mix. An Optimum Bitumen Content is selected for both grades by the Marshal stability method. The moisture susceptibility of the bituminous concrete is investigated by conducting the Retained Marshall test on asphalt specimens both in unaged and aged bituminous concrete mixes. The impact of using eggshell powder and cement powder as fillers on various performance parameters, including Marshall stability, flow, volumetric properties, and moisture susceptibility of the asphalt mixtures are evaluated.

4. RESULT AND ANALYSIS

4.1Obtimum Bitumen Content (OBC) For VG30

Results showing the OBC value for VG 30

S. No	Bitumen Content (%)	Theoretical Specific gravity	Bulk specific gravity	Air Voids (%)	VMA (%)	VFB (%)	Corrected Stability (kN)
1	4.5	2.46	2.24	8.97	18.43	51.36	17.27
2	5.0	2.45	2.34	4.29	15.23	71.83	17.48
3	5.5	2.43	2.33	4.36	16.25	73.18	23.64
4	6.0	2.42	2.33	3.35	16.30	79.4	17.75



Graph 1. %air voids v/s binder content

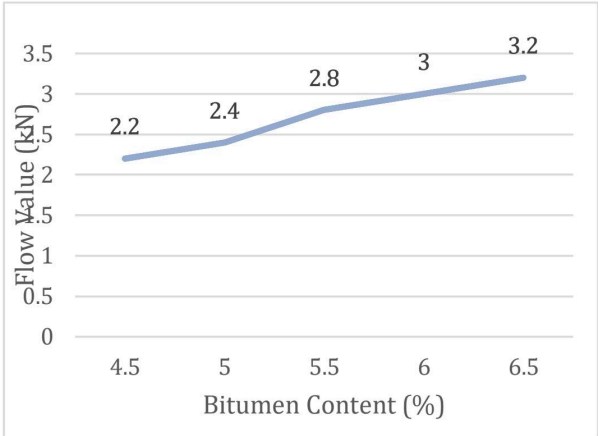


Figure 2: Graph on % Bitumen content Vs Flow value

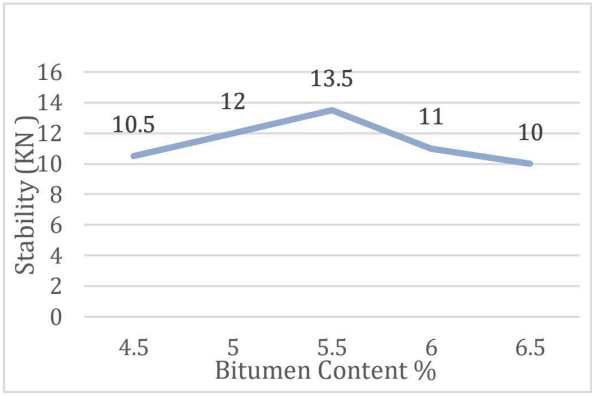


Figure 3: Graph on % Bitumen content Vs Stability

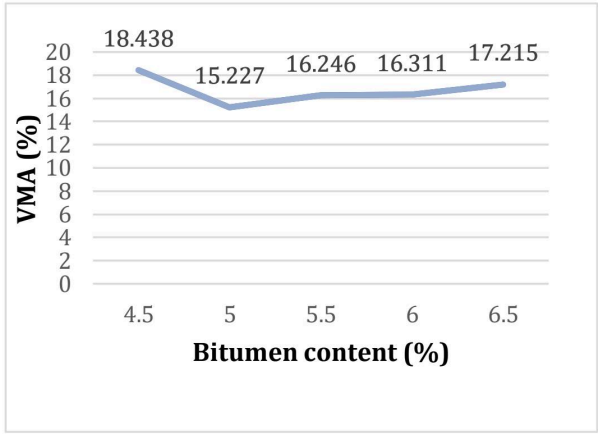


Figure 4: graph on % Bitumen content Vs % VMA

International Journal of Engineering Research & Technology (IJERT)
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 05, May-2023

4.2Optimum Bitumen Content for NRMB

Results showing the OBC value for NRMB 70

S.no	Bitumen Content (%)	Theoretical Specific Gravity	Bulk Specific Gravity	Air Voids	VMA (%)	VFB (%)	Corrected Stability (kN)	Flow Value
1	4.5	2.44	2.32	4.8	6.62	27.46	18.98	3.12
2	5	2.45	2.18	10.78	12.92	16.55	15.01	2.67
3	5.5	2.43	2.34	3.74	5.92	36.88	17.72	2.85
4	6	2.42	2.38	1.59	3.93	59.47	23.89	4.10
5	6.5	2.4	2.40	0.02	2.51	99.26	18.82	3.05

Optimum Bitumen Content = 5.48%

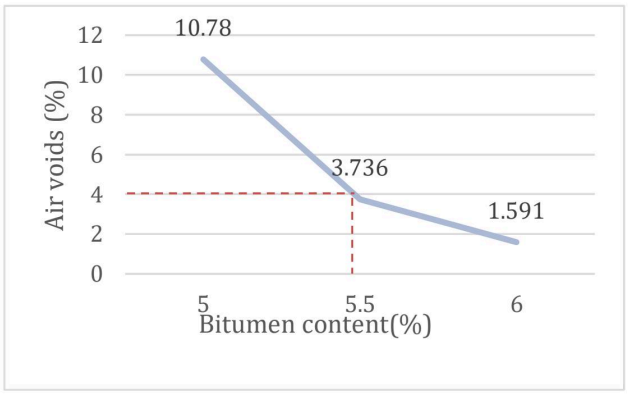


Figure 5: Graph on % Air voids Vs % Binder content

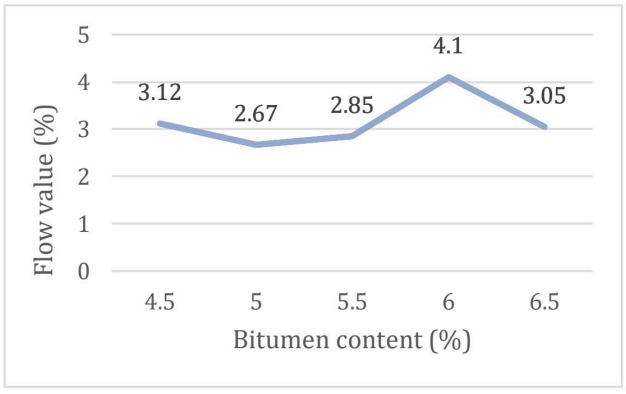


Figure 6: Graph on % Bitumen content Vs % flow value

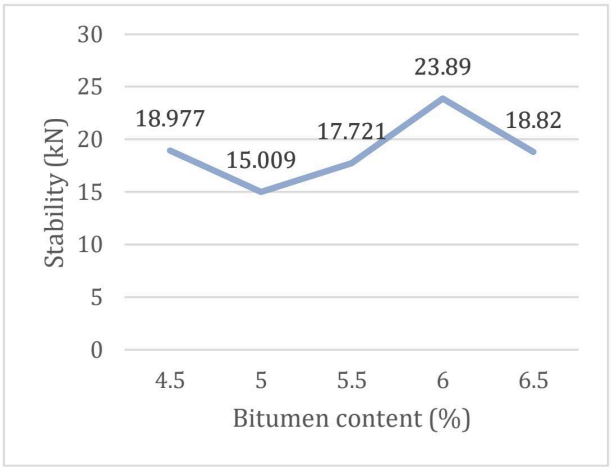


Figure 7: Graph on % Bitumen content Vs Stability

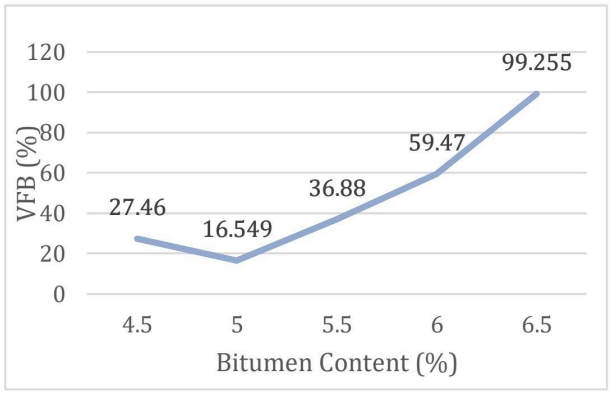


Figure 8: Graph on % Bitumen content Vs % VFB

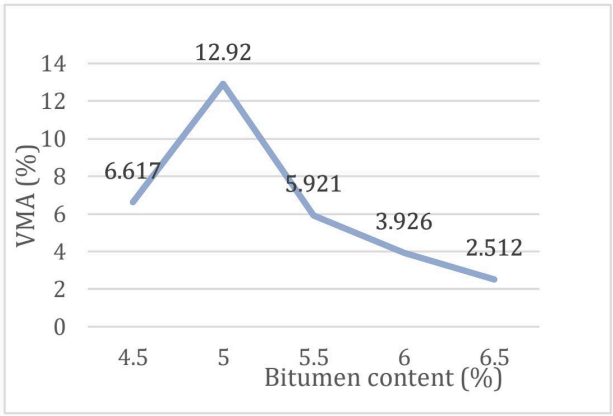


Figure 9: Graph on % Bitumen content Vs % VMA

International Journal of Engineering Research & Technology (IJERT)
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 05, May-2023

4.3 MARSHAL STABILITY AND RETAINED MARSHAL STABILITY VALUE FOR VARIOUS BITUMEN MIXES

Sl.No.	Bituminous Mix	Marshal dry	Marshal wet
1	VG 30, unaged	15.375	12.635
2	VG 30, aged	14.3885	11.3085
3	NRMB, unaged	19.295	17.75
4	NRMB, aged	18.125	15.125
5	VG30+eggshell powder (unaged)	20.74	18.775
6	VG 30+eggshell powder (aged)	18.365	15.215
7	VG 30+cement powder (unaged)	21.46	17.885
8	VG 30+cement powder (aged)	16.645	15.32
9	NRMB+eggshell powder (unaged)	21.532	18.3
10	NRMB+eggshell powder (aged)	15.705	15.26
11	NRMB+cement powder (unaged)	21.99	19.075
12	NRMB+cement powder (aged)	16.9935	16.113

5.RESULTS AND DISCUSSIONS

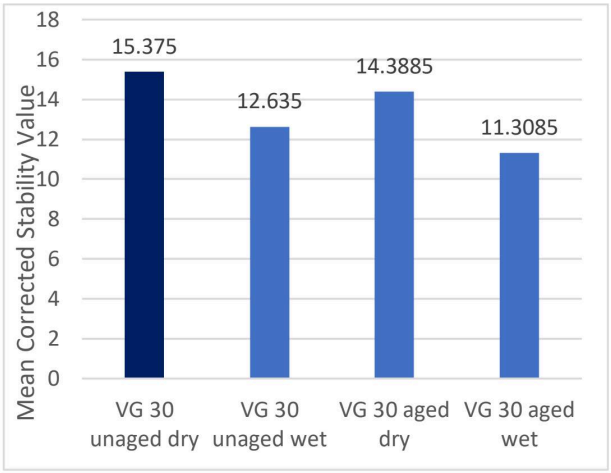


Figure 10: Comparison bar chart for VG 30

- In unaged bituminous mix of VG 30, 82.17 % of initial stability value observed after moisture susceptibility test
- After ageing 93.5 % of initial stability value is observed
- When aged bituminous mix of VG 30 is subjected to moisture susceptibility test only 73.5 % of initial stability value is observed.
- In unaged bituminous mix of NRMB grade, 92 % of initial stability value is observed after moisture susceptibility test

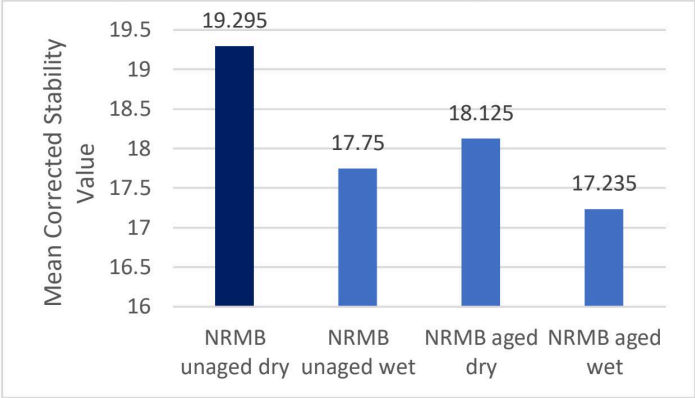


Figure 11: Comparison bar chart for NRMB

- After ageing 93.9 % of initial stability value is observed
- When aged bituminous mix of NRMB is subjected to moisture susceptibility test only 77 % of initial stability value is observed.

ADDITION OF FILLERS IN BITUMINOUS MIXES

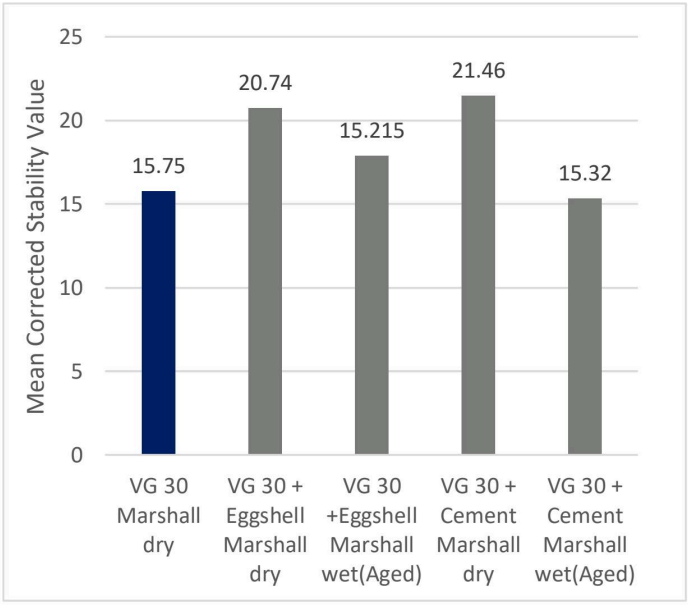


Figure 12: Comparison bar chart for VG 30 bituminous mixes added with different fillers.

- When eggshell powder is added as filler in VG 30 Marshall stability value increases by 35 % from initial stability value.

International Journal of Engineering Research & Technology (IJERT)
International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 12 Issue 05, May-2023

- When cement is added as filler in VG 30 marshall stability value increased by 39 % from initial stability value
- When VG 30 bituminous mix containing cement powder as filler undergone both ageing and moisture conditioning, 99 % of initial stability value is observed.
- When VG 30 bituminous mix containing eggshell powder as filler undergone both ageing and moisture conditioning, 98 % of initial stability value is observed. (Initial stability value represents Marshall stability value observed for unmixed, unaged bituminous mix)

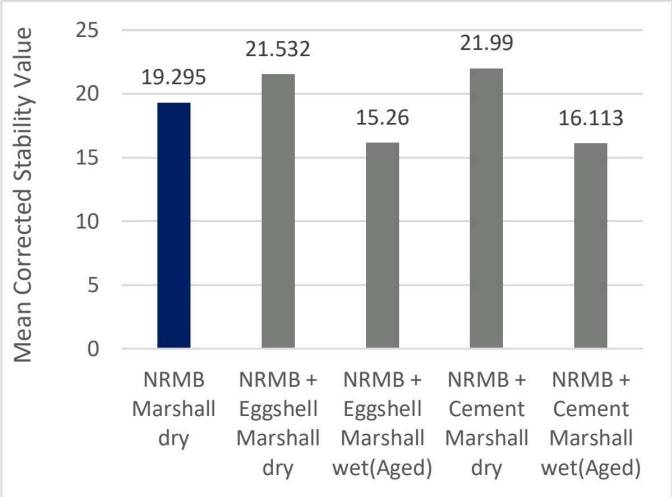


Figure 13: Comparison bar chart for NRMB bitumen mixes added with fillers.

- When eggshell powder is added as filler in NRMB marshall stability value increased by 12 % from initial stability value
- When cement powder is added as filler in NRMB stability value increased by 15 % from initial stability value
- When NRMB bituminous mix containing cement powder as filler undergone both ageing and moisture conditioning, only 83.5 % of initial stability value is observed.
- When NRMB bituminous mix containing eggshell powder as filler undergone both ageing and moisture conditioning, only 80 % of initial stability value is observed.

CONCLUSIONS

- Moisture susceptibility of asphalt mixtures is a complex phenomenon. The moisture related damage would lead to pavement distresses such as rutting, cracking, raveling, weathering and the creation of potholes. Therefore, to learn more about bitumen's behaviour in the presence of moisture, we selected our project to investigate moisture susceptibility of aged bitumen.
- Bitumen hardens, has less adhesion, cracks, and ruts as it ages. When bitumen mixes are subjected to ageing in laboratory oven from the experiment results, Overall stability value of NRMB decreased by 8% and for VG 30 a decrement of 17% is observed from initial stability value, thereby compared to VG30, NRMB has minimal effect on ageing.
- Aged bitumen tends to exhibit increased susceptibility to moisture damage compared to unaged bitumen.VG30 grade bitumen shows higher moisture susceptibility than NRMB grade bitumen. Also, moisture susceptibility of aged bituminous mix can be influenced by various factors, including the type and amount of asphalt binder used, aggregate properties, pavement design, construction practices, and environmental conditions.
- When eggshell powder and cement powder is added as filler in bituminous mixes, an increment of Marshall stability value is observed, from the results cement powder have more performance.
- NRMB have more moisture resistance compared to VG30, Also NRMB have more ageing resistance, thereby we prefer NRMB suits more for Kerala's tropical climate., However, the suitability of an asphalt mix for a specific region like Kerala depends on several other factors as well, including climate, traffic volume, environmental conditions, and the type of road., pavement specialists, and relevant authorities who have a thorough understanding of the region's conditions. provide more accurate and site-specific recommendations for choosing the most suitable asphalt mix for road construction in Kerala.

Overall, this study represents a significant step towards understanding the complex interplay between bitumen aging, moisture susceptibility, and the incorporation of innovative fillers, paving the way for more resilient and sustainable road construction practices.

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International Journal of Engineering Research & Technology (IJERT)
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Vol. 12 Issue 05, May-2023

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