Experimental Analysis on the Factors Influencing the Viscosity Property of Bitumen

Akshatha M. [1], Suhas H B[2], Bindiya K[3], Amith S[4,] Shreesha H S[5] and Nandeesh K S[6]
[1,3]*Assistant Professor, Jawaharlal Nehru New College of Engineering*
[2,4,5]*Student, Jawaharlal Nehru New College of Engineering*

***Abstract*—Bitumen, a vital binder in asphalt mixtures, exhibits unique rheological properties, with viscosity being one of its key characteristics influencing its performance in pavements. The viscosity of bitumen is essential for determining its workability, durability, and resistance to deformation under various environmental and loading conditions. This study examines the factor affecting the viscosity of bitumen, including temperature, aging, chemical composition, and the presence of modifiers. Temperature is a primary factor as bitumen viscosity decreases with rising temperatures, affecting ease of mixing and compaction in road construction. Aging impacts viscosity due to oxidation and volatilization, leading to a stiffer and more brittle material over time. Chemical composition, particularly the proportion of asphaltenes and maltenes directly influences the viscosity levels, while polymer additives can enhance bitumen's resistance to temperature changes and stress. Understanding these factors is crucial for optimizing bitumen properties to improve road performance, extend service life, and reduce maintenance costs. Present study focuses on analysis of rheological properties of bitumen at various temperature to arrive at a relationship between flow and temperature.**

***Index Terms*—Viscosity Grade (VG), Polymer Modified Bitumen (PMB), Centistoke (cSt)**

I. INTRODUCTION

Viscosity is one of the most critical properties of bitumen, a key material in the construction of roads and pavements.it determines the fluidity and workability of bitumen under various temperatures and is crucial for the material's performance, durability, and resistance to deformation under traffic loads. The viscosity of bitumen directly influences its mixing, handling, and application in road construction. Several factors affect the viscosity of bitumen, impacting its behavior and stability over time. One of the primary factors influencing viscosity is temperature. Bitumen becomes more fluid as the temperature increases, making it easier to mix and compact, while lower temperature causes it to stiffen, which may lead to cracking under stress. Aging also significantly affects viscosity; as bitumen is exposed to oxygen, sunlight, and heat over time, it undergoes oxidation and volatilization, increasing its viscosity and making it harder and more brittle.

The chemical composition of bitumen, including the proportions of asphaltenes, resins, and oils, also plays a crucial role in determine viscosity. Higher asphaltene content generally increases viscosity. Higher asphaltene content generally increases viscosity, resulting in a stiffer material. Additionally, the inclusion of modifiers like polymers or recycled materials can alter the viscosity and improve temperature susceptibility, extending the material's functional range.

By understanding and managing these factors, engineers and material scientists can optimize bitumen for specific environmental and traffic condition, enhancing road performance, safety, and longevity. This introduction provides an overview of these key factors, setting the stage for further exploration into how they affect bitumen's viscosity and overall performance.

Bitumen is a viscous, black, sticky material derived from the distillation of crude oil. It is commonly used in construction and road paving due to its adhesive and waterproofing properties. Composition Bitumen is a complex mixture of hydrocarbons and other organic substances, which include:

Carbon (80–87%)
Hydrogen (8–11%)
Sulfur (up to 7%)
Trace amounts of nitrogen, oxygen, and metals.

1.1 Types of Bitumen

Natural Bitumen: Found in natural deposits, such as tar sands or rock asphalt.

Refined Bitumen: Obtained as a byproduct during the fractional distillation of crude oil in oil refineries.

1.2 Properties

Adhesive: Bitumen binds aggregate in asphalt, forming a durable surface.

Waterproofing: Prevents water penetration, making it ideal for roofing and damp-proofing.

Viscosity: Varies with temperature; it softens when heated and hardens when cooled.

Durability: Resistant to weathering and chemical corrosion.

1.3 Uses:

Pavements /airports.

Waterproofing: Used in roofing, dam linings, and underground structures.

Industrial Applications: As a binder in pipe coatings, paint, and adhesive formulations.

1.4 Production Process:

Crude oil undergoes fractional distillation, and bitumen is extracted from the heavier fractions. Additional processes, such as oxidation or polymer modification, may enhance its properties.

1.5 Environmental Considerations:

While bitumen is effective for infrastructure, it has environmental challenges: Non-renewable: Derived from fossil fuels.

Emissions: Production and heating release greenhouse gases.

Recyclability: Old asphalt can be recycled to reduce waste.

1.6 Methods of classification of bitumen:

Bitumen is classified generally as penetration grade and viscosity grade as mentioned in the Table No 1.1 and 1.2 respectively.

1.7 Importance of Viscosity Grade:

The Viscosity Grade (VG) of Bitumen is critical for ensuring the performance and durability of asphalt pavements and other bituminous applications. It provides a reliable measure of bitumen's flow behavior and workability at different temperatures, which directly impacts construction quality and long-term performance.

Table.1.6.1 - Penetration Grade

Grade	Application
30/40	Heavy traffic roads, hot climates
40/50	Durable pavements industrial applications
60/70	Standard road construction (most common)
80/100	Cold climates, traffic roads
	Light -duty roads, temporary construction

Table.1.6.2 – Viscosity Grade

Viscosity Grade	Typical Uses
VG-10	Spraying applications like surface dressing, bituminous emulsion production, cooler climates.
VG-20	Cold climatic conditions, road construction in areas with mild temperatures.
VG-30	Paving roads in hot and moderate climates, standard road construction.
VG-40	High-traffic roads, highways, and industrial applications in hot climates.

Here's why viscosity grading is important:

Performance Under Various Temperatures: Hot Climates: VG ensures that bitumen remains stable and resis-ts deformation (e.g., rutting) under high temperatures.Cold Climates: VG helps prevent cracking by ensuring flexibility and adequate flow at lower temperatures.VG grading accounts for the temperature range a pavement will face, making it more reliable for diverse climatic conditions compared to other grading systems.

Improved Pavement Durability: Bitumen with the correct viscosity ensures strong adhesion with aggregates, reducing the chances of disintegration. Viscosity-graded bitumen is less prone to thermal susceptibility, improving its resistance to aging, oxidation, and weathering.

*Accurate Material Selection:*Viscosity grading allows engineers to select bitumen with properties tailored to the specific conditions of a project, such as:

Traffic Load: Higher viscosity grades (e.g., VG-40) for roads with heavy traffic.

Climatic Conditions: Softer grades (e.g., VG-10) for colder regions.

*Ensures Quality During Construction:*VG considers the workability of bitumen at high temperatures

(135°C), ensuring it can be mixed with aggregates and laid efficiently during paving. Proper viscosity helps avoid issues like improper compaction or segregation of materials during construction.

Reduces Risks of Pavement Failures: High Viscosity (VG-40): Prevents softening, bleeding, and rutting in hot climates and heavy-traffic conditions. Low Viscosity (VG-10): Ensures sufficient flexibility in colder regions to prevent brittle failures.

Better Than Penetration Grading Consistency: Viscosity grading measures bitumen's flow properties more accurately than penetration grading, which only assesses hardness.

Enhanced Life Cycle Cost: Using the right viscosity grade reduces maintenance needs and extends the lifespan of pavements, saving costs over time.

II. METHODOLOGY

For the present study the fresh bitumen sample was collected from HINCOL which is a leading manufacturer of Bitumen derivatives. Samples of VG 10, VG30 and VG 40 was used for carrying out the present study. Penetration test, softening point test and Kinematic viscosity test for the collected sample was done as per the standard test procedure and the result are tabulated in the following table 2.1, 2.2 and 2.3 for VG 10, VG30, VG 40 respectively

Table.2.1 – Test results of VG 10

VG 10	Standard Value	Obtained value
Kinematic Viscosity, cSt	250 min	256
Penetration Grade , mm	80-100	81.3
Softening Point	40	40.2

Table.2.2 – Test results of VG 30

VG 30	Standard Value	Obtained value
Kinematic Viscosity, cSt	350 min	350
Penetration Grade , mm	50-70	57
Softening Point	47	41.3

Table.2.3 – Test results of VG 40

VG 40	Standard Value	Obtained value
Kinematic Viscosity, cSt	400 min	400
Penetration Grade , mm	40-60	47
Softening Point	25	52.5

III. RESULT AND CONCLUSION

Following are the outcome of the present study.

1. All rheological properties of the selected bitumen samples are will within the standard values (Table 2.1, 2.2 and 2.3)
2. VG – 10 with penetration Value of 81.3 mm is being softer bitumen when compared to VG 40 of penetration value 47mm
3. VG40 with softening point value of 47.1ºC can be heated up to this temperature and so being VG10 with low temperature sustainability value of 40.2 ºC
4. The more accurate method of specifying binder consistency and a more effective method of determining the temperature sustainability of the bitumen is viscosity test and then viscosity value obtained from VG 40 being higher when compared to VG30 and VG10.

REFERENCES

[1] Z. Zhou and G. Chen. (2021). Preparation, Performance, and Modification mechanism of high Viscosity modified Asphalt.
[2] D. A. Al Shehri, M. Mahmoud, and S. Oluseaun. (2021). Viscosity models for bitumen- solvent mixture.
[3] M. Holy and E. Remisisova. (2019). Analysis of Influence of Bitumen composition on the properties represented by Empirical and Viscosity test.
[4] S. S. Kar, A. K. Swamy, D. Tiwari, and P. K. Jain. (2018). Impact of low viscosity grade bitumen on foaming characteristics.
[5] M. Maheshwar. (2018). A review article on measurement of viscosity.
[6] S. A. Yero and M. R. Hanin. (2012). Viscosity Characteristics of Modified Bitumen.
[7] D. Q. Sun. (2010). Factor affecting the Viscosity of Crumb rubber-modified asphalt.

[8] R. L. Griffin, T. K. Miles, and W. C. Simpson. (1959). Influence of composition of Paving Asphalt on viscosity, Viscosity- temperature susceptibility and durability.