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A Comparative Study on Conventional Bitumen Concrete Mix and Ethylene Vinyl Acetate Modified Bitumen Concrete Mix

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ABSTRACT- Bitumen is often used in the building of flexible pavements in the capacity of a binder. In the current investigation, it is suggested that the characteristics of bitumen might be improved by modifying it with EVA polymer. The useful life of pavements may be shortened as a consequence of rutting. In the event that the rutting depth is very severe, water may pool in the pavement area, which may cause vehicles to hydroplane.
The results of a bending beam rheometer test (BBR) for creep stiffness at lower temperatures indicate that the creep stiffness of modified bitumen was lowered, while the m-value was enhanced. The in-situ polymer modified binders that were produced demonstrated significantly reduced stiffness and satisfied the required parameters up to a temperature of -18 degrees Celsius.

KEYWORDS- Bitumen, Paving Bitumen, Bitumen Concrete Mix, Ethylene Vinyl Acetate

I. INTRODUCTION

Since ancient times, bitumen has been used in the construction industry as a material for building, as well as a sealant, adhesive, and waterproofing agent [1]. In the year 2000 B.C., the Babylonians used asphalt as a binding medium when they constructed structures such as bridges, wells, tunnels, sewers, highways, and the Tower of Babel. Around the year 300 BC, the civilizations of Harappa and Mohanjo-dero, which were located in the Indus valley, employed asphalt to waterproof their toilets. In biblical times, the ark of Noah was sealed with asphalt to prevent water leakage. Under the reign of the Pharaohs, the Egyptians mummified their deceased using a variety of substances, including bitumen obtained from the Dead Sea [2].
Bitumen is created when organic matter from the water, such as dead plankton, algae, and other organic material, is accumulated on the ocean bottom [3] .Asphalt comes produced oil products, mainly comes through marine creatures. After thousands of years, heating and the pressure of the earth's crust transform biocompatible material become oil products. The crude oil will ultimately be stored in enormous subterranean reservoirs that are formed when it is encased in impermeable rock. The crude oil has the potential to sometimes rise via faults in the strata that are located above it and make its way to the ground's surface. The chemical make-up of crude oil consists mostly of several types of hydrocarbons, differing amounts of non-hydrocarbon components, and traces of various metals. Drilling is presently the primary method used to obtain crude oil from subsurface [3].

A. Chemistry of Bitumen

The non-crystalline substance known as bitumen, which may be black or dark brown in color, is quite soluble in the solvent known as carbon disulphide (CS2). The bitumen that is derived from various types of crude oil has a unique chemical make-up of distinct types of hydrocarbons. The amount of bitumen that is found in crude petroleum oil might range anywhere from 10 to 40 percent, or possibly a greater proportion. The residue that is left behind after distilling crude oil is used to categorize the crude into one of three broad types. These types are:

- Bitumen,
- paraffin-based, and
- Bitumen and paraffin-based

Asphalt is a higher methane mixture with significant quantities of heterocyclic rings. Elevated compounds with oxygen, nitrogen, oxygen, and sulphur. Chemically speaking, bitumen is a black, sticky substance. These heteroatoms provide the molecules functionality and polarity, and they may contribute to the characteristics of bitumen in a proportional way [5]. The majority of the time, heavy metals like as vanadium and nickel may be found in very minute quantities as traces of inorganic salts and oxides or as components of porphyrinic structures [6]. Even though there is only a trace quantity of these functional groups in the bitumen, they have a significant impact on the characteristics of the bitumen as well as its interaction with other elements like stone aggregates.

Table 1: The Composition of Bitumen Based on Its Elements

Element	Range (%)
Carbon	88-82
Hydrogen	11-8
Sulphur	6-0
Nitrogen	1-0
Oxygen	1.5-0

B. Production of Bitumen

Only a select few of the large range of crude oils that are offered for sale on the market are thought to be appropriate for the production of bitumen that is up to the needed standard. The amount of bitumen that is found in crude petroleum oil may range anywhere from ten percent to forty percent, or possibly a greater proportion. An overview of the most important procedures carried out in a refinery is shown in the accompanying diagram (Figure 1).

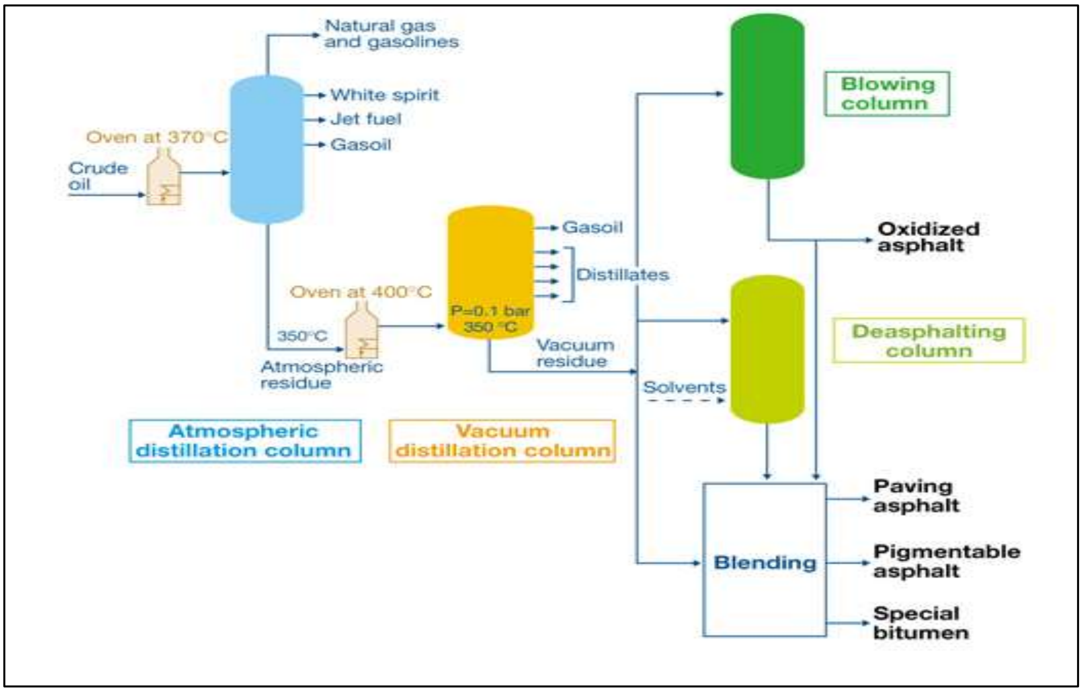

Figure 1: Procedures carried out in a refinery

C. *Bitumen Characterization Using Various Test Methods*

In the 19th century, standard testing procedures like as infiltration, softening point, and viscosity were used to measure the value and uniformity of asphalt binders. Other typical testing methods include elongation at break, which measures the amount of stretch in a material. This category of conventional bitumen grades is referred to as the penetration grade. The softening point and the techniques of penetration testing are what are used to define the penetrability grade.

i. *Penetration*

The consistency of the bitumen is evaluated using the penetration technique under predetermined standard parameters consisting of time (five seconds), temperature (25 degrees Celsius), and weight (100 g). The procedure for the test is outlined in specification of ASTM D5.

ii. *Viscosity*

Time required for bituminous compound to flow through it with a calibrated glass viscometer, is what's measured while conducting viscosity tests. Viscosity readings are taken at temperatures of 60 and 1400C. Absolute viscosity is determined by drawing bitumen through a viscometer under vacuum at 60°C. Kinematic viscosity estimates bitumen's the flow under its own weight at 135°C. Kinematic viscosity is related to dynamic viscosity of the bitumen binder that measures the duration it takes for a specific amount of substance to flow through some kind of standardized aperture.

Kinematic viscosity is related to dynamic viscosity of the bitumen binder. At the moment, a standard known as IS: 73 (4th revision) (Table 2) is being adhered to across the board for road construction projects in India.

iii. *Softening Point*

Bitumen's softening point refers to the temperature at which bitumen-encased balls may roll down a slope of 25 mm into the bottom plate without breaking. The softening point is determined by testing the temperature susceptibility of the bituminous binder across a range of temperatures from 30 to 157 degrees Celsius using the ring and ball equipment while it is submerged in either distilled water or ethylene glycol.

D. *Superior Performing Asphalt Pavements (Superpave) Test*

The softening point and the penetration merely measure the bitumen's properties. Specimen at a certain degree of temperature, but they don't provide any clear explanation of how they did it. The binder would function well throughout a broad temperature range, in contrast to the bituminous pavement may ordinarily endure during the period when road work is taking place, and also throughout the course of its existence. As a result, we cannot rely on the results of these tests since they are empirical.

E. *Supply & Demand Scenario of bitumen in India*

To accommodate the growing volume of very heavy traffic—both in terms of the total number of vehicles and their axle loads—the economy of India, which is expanding at the fastest rate in the world, will require a reliable road transport network with a pavement structure of the highest possible quality. Due to the rapidly increasing demand for Indian road transportation infrastructure, the country's road network is now experiencing a demanding development of high quality pavement structure. In addition, the sector has seen significant price increases in bitumen binder over the course of recent years. Bitumen demand is being fueled in large part by the fact that India is one of the world's biggest and fastest-growing markets for the material. This has led to a major increase in the amount of high-quality bitumen and bituminous products that must be imported to keep up with domestic demand.

Table 2: Prerequisite for Paving Bitumen (4th revision is: 73; *clause* 6.2)

S. No.	Characteristics	Paving Grade				Reference to IS No.
		VG 10	**VG 20**	**VG 30**	**VG 40**	
1	Penetration at 25ºC, 100g, 5 s, 0.1 mm, min	80	60	45	35	IS 1203
2	Absolute viscosity at 60ºC, Poises	800–1200	1600-2400	2400-3600	3200-4800	IS 1206 (Part 2)
3	Kinematic viscosity at 135ºC, cSt, Min	250	300	350	400	IS 1206 (Part 3)
4	Flash point, (Cleveland open cup), ºC, Min	220	220	220	220	IS 1448
5	Solubility in trichloroethylene, %, Min	99	99	99	99	IS 1216
6	Softening point (R&B), ºC, min	40	45	47	50	IS 1205
Tests on residue from rolling thin film oven test (RTFOT)						
7	Viscosity ratio at 60ºC, Max	4.0	4.0	4.0	4.0	IS 1206
8	Ductility at 25ºC, cm, Min,	75	50	40	25	(Part 2) IS 1208

II. LITERATURE REVIEW

A. Antistripping Additives for Bitumen

Because bitumen in its natural state is not ideal for modern roads and the intense traffic that they experience today, engineers have been obliged to alter bitumen in order to enhance its performance while it is in service [15]. The redesigned binders demonstrate higher resistance to permanent deformation in hot weather and show improved stability when subjected to large loads, braking forces, and acceleration forces. It can withstand fatigue stresses and has greater adherence of aggregates with binders than other materials.

Results from a literature analysis indicate that antistripping compounds have been routinely added to bitumen across the world for many years. Organic and inorganic molecules alike have been explored over a spectrum of chemistry. Curtis presented examples of several essential additions that had been employed in the previous within his research essay titled "Liquid Antistripping Chemicals." These primary alkyl amines, such as lauryl amine and stearyl amine, as well as the alkylene diamines, particularly the alkyl-substituted alkylene diamines, such as N-stearyl-1,3-propylene diamine, were cited as some of the Carlo Gravarini and G. Rinaldi discovered that a compound obtained from the reaction of tetra ethylene pentamine (TEPA) with formaldehyde (CH2O) has excellent antistripping properties [17]. Regarding unique paving building sites wherever petroleum or chemical resistance is needed, starches might well be employed to provide a more cost-effective binder amendment for road pavements, as stated by Al-Handy [18]. Evans E.D. stated that the result of the reaction between ozonized fatty acids and polyamines have a substantial antistrip property [19]. Sawatzky, H found that the addition of a nitrogen-containing portion to sewage sludge improved the asphalt's ability to adhere to the comprehensive in bitumen concrete [20]. Rick A mentioned the usage of Tall Oil in order to improve the degree to which bitumen adheres to mineral aggregates [21]. Hesberger described the use of dihydroxy aluminum sulphonates in bitumen in the capacity of antistripping agent [22]. Treatment of aggregates with cationic type surfactants was advocated by Jack N. Dybalski of the Armak Company [23] in order to get the highest amount of antistrip behavior.

Lime has been observed as being used as an antistrip agent by D.N. Little and Jon A. Es [24]. Lime does have a number of benefits beyond just preventing stripping, including hardening asphalt cement binders, preventing fracture growth at low temperatures, slowing the effects of aging, and changing bitumen's plastic behavior. Lime also has the ability to alter the plastic properties of bitumen. According to the assessment of published material, there have been reports in the literature of some chemical changes. According to Shukla [25], bis (2-hydroxyethylene) terephthalamide (BHETA) may be produced from PET and ethanolamine in about 8 hours using acetic acid, sodium acetate, and potassium sulfate as a reagent.This method was successful in producing BHETA.

B. Poly (ethylene terephthalate) (PET)

Terephthalamide compounds developed from polymers of the ethylene terephthalate (PET) polymer as innovative antistripping agents. An additive for bitumen that is favorable to the environment and a method for the disposal of waste[9][10]. The chemical known as polyethylene terpthalate, or PET, has the potential to be a major contaminant to the environment. It has been known for quite some time that aminolysis of PET may be used as a method to chemically breakdown the material into monomers and oligomers for the goal of recycling. According to the information in the relevant literature, the use of such deteriorated goods for large-scale industrial applications has only been witnessed in a restricted number of applications[11][12]. The current research highlights the development of a straightforward aminolysis method that is based on green chemistry, with the goal of converting ecologically toxic waste into anti-stripping chemicals that are beneficial in industry and are utilized in bitumen. During the course of the research, it was discovered that doping bitumen with a product derived from PET improves the properties of bitumen by making it less susceptible to damage caused by the intrusion of moisture, while at the same time allowing the bitumen to maintain all of its other properties[13][14].

Bitumen is a black non-crystalline thermoplastic viscous substance used for millennia as an adhesive, sealant and water proofing agent. Bitumen is modified with a number of additives and broadly classified polymeric and other chemical modifiers. Heavy loads, greater tyre pressure and increasing traffic are stressing roadways, triggering early breakdowns[26].

III. EXPERIMENTAL PROGRAM

A. Experimental

i. *Materials*

a) Chemicals

Triethylene tetramines (TETA), Ethanolamine, 4,4-diphenylmethane diisocyanate (MDI) and xylene were of Laboratory Reagent (LR) grade.

b) Aggregates

Utilizing aggregates that could be found nearby, which had a particle size of 100% retained on a 13.2-mm sieve and 100% passed through a 19-mm screen, The aggregates were cleaned in distilled water to eliminate all particles, dried to a constant weight between 105 and 110 0C, and then kept in airtight containers until needed.

c) Aggregate Gradation Adopted

According to Ministry of Road Transport and Highways (MORTH: 2000) Specifications, the grading of the aggregates for the bituminous mixes chosen for this research was completed and is shown in Table 3.

d) Bitumen

The Indian Oil Mathura refinery provided bitumen (VG 10 grade) in accordance with BIS specification IS: 73-2006. In Table 3, common bitumen qualities are listed.

e) Polyethylene terepthalate (PET)

In the course of our research, we made sure to make use of both bottle grade and virgin PET polymer while we were manufacturing PMB. The local market provided us with discarded PET bottles that we purchased. The labels on the plastic bottles were removed, and once the bottles had been emptied of their contents and their labels removed, they were sterilized by adding a detergent solution to boiling water, then washing, and finally drying, in order to eliminate any possible pollutants. After that, the bottles were sliced into little squares (flakes) measuring approximately 1 millimeter by 1 millimeter and dried at room temperature.

Table 3: Recommended Aggregate Grading System for Bituminous Mixtures

Sieve size (mm)	Specified limits	
	Sieve size (mm) passing	Percent Adopted
19	100	100
13.5	75-100	90
9.5	72-90	85
4.75	55-75	65
2.36	45-62	55
1.18	36-50	40
0.6	27-38	30
0.3	20-30	20
0.15	10-18	15

ii. Methods

Synthesis of terephthalamide Derivative The experimental approach for the aminolysis reaction of PET waste was carried out in accordance with the method that was disclosed before by our team [8].

The components have been installed in a three-necked, 500-milliliter round-bottomed flask with heating mantle, overhead stirrer, water condenser, nitrogen gas sparging tube, and thermo well pocket housing a thermometer: You'll need 30g of PET polymer, 90ml of toluene, and 90g of amine (such triethylene tetramine (TETA) or ethanol amine) to make 1l of solution. It was ensured that a steady current of dry nitrogen was maintained. Eight hours were spent with the combination in a refluxing vessel. When the breakdown of PET was finally finished, the solution turned out to be uniform. On the assumption of the reaction, some unreacted polyamine and glycol was present were extracted using a vacuum.

B. Producing Poly(Methyl-Bis-Bis-Acrylamide) (PMB) In Situ

In the study that is being presented here, BHETA and TETAterephthalamide, two different kinds of terephthalamide, were used. In bitumen, this terephthalamide had a reaction with MDI at the relevant weight-to-weight ratios of (3:1.5:95.5). The reaction mixtures were heated for four hours at temperatures ranging from about 90 to 1300 degrees Celsius while being vigorously stirred in an environment of nitrogen. Both of these peaks would be ascribed to the carbonyl group. A distinctive absorption peak can be seen between 3273 and 3442 cm1 from the N–H group that is involved in the hydrogen bond. The infrared spectra of all of the polyurea are very identical, and an analysis of all of the spectra indicates that the spectra are composed of urea linkages. The urea connection may be verified by the IR bends that occur at 1663-1609 cm-1 and 1234-1220 cm-1.

C. Mixing and compaction temperatures

The temperature of the bitumen binder was raised to 170 0 C in order to get the desired kinematic viscosity of 170 20 x 10-6 m2/s for mixing. A compaction temperature of 150 0 C was chosen in order to achieve the viscosity of 280 30x10-6 m2/s.

IV. RESULT AND DISCUSSION

Table 4: Properties of Neat VG-10 & In-Situ PMB

Properties	VG-10 Bitumen	TETA terephthalamide Mod. Bitumen	BHET Aterephthalamide Mod. Bitumen	SBS Mod. Bitumen	PMB-grade-3 (IRC:SP:53-2010)
Penetration 25^{0}C (100g, 5s), 0.1mm	90	72	70	72	60-120
Softening Point ^{0}C	57	65	62	60	50 Min
Ductility at 27^{0}C (5 Cm/Min)	122	105	55		---
Elastic recovery at 15 ^{0}C (%)	-	42	34	70	
Viscosity (at 150 ^{0}C) (Poise)	1.64	2.55	3.08	3.15	1-3 poise
Separation diff. (in Softening Point ^{0}C)	---	2.5	3	1	3 Max

A. Dynamic Shear Rheometer (DSR)

It is usual practice to investigate the rheological characteristics of bitumen by using dynamic mechanical techniques and testing of the oscillatory variety. These oscillation tests are carried out with the assistance of a dynamic shear rheometer (DSR), which delivers oscillating shear stresses and strains to samples of bitumen that are sandwiched between parallel plates and subjected to a variety of loading frequencies and temperatures. When it comes to assessing the deformation properties of modified bitumen for use in road surface applications, the dynamic shear rheometer, abbreviated as DSR, is the approach that is used most often. A DSR (of the Physica Anton Par 300 manufacture) that has been outfitted with a circulating water bath that allows for temperature control of the sample may be used to do measurements of the complex shear modulus, denoted by the symbol G*.

At high temperatures, the rutting resistance of the produced product is significantly improved by increasing the G*/Sin(o) ratio. This is the case in order to provide suitable resistance against rutting. Within the temperature range of 58-82 degrees Celsius. Table 5 presents the findings obtained from the DSR. According to the findings, all of the changed bitumen samples had G*/Sin() values that were greater than those of the unmodified bitumen. According to Table 3, the G*/Sin() values of all modified bitumen are 1.23 and 1.16 kPa for unaged and 2.84 and 2.22 kPa at 70 0C for the RTFO aged TETA-terephthalamide modified bitumen and BHETA-terephthalamide modified bitumen, respectively. These values are based on the unaged modified bitumen. Therefore, modified bitumen samples that were stored in non-aged circumstances as well as RTFO samples that were stored in aged settings exhibited values that were acceptable up to a temperature of 70 degrees Celsius. This suggests that in-situ modified bitumen displays better stiffness values in comparison to unmodified bitumen.

Table 5: Dynamic Shear Rheometer Results

Properties Test	Temp. (^{0}C)	VG-10 Bitumen	TETA Modified Bitumen	BHETA modified bitumen	SBS based Modified Bitumen	PMB-grade-3 (IRC:SP:53-2010)
DSR of (unaged samples)	58	2.14	5.32	4.93	3.15	
	64	0.92	2.55	2.35	1.42	
	70	0.42	1.23	1.16	0.64	
	76	0.2	0.639	0.519	0.29	
DSR of RTFO aged	58	3.99	11.34	10.67	6.1	
	64	1.71	5.49	4.96	3.15	
	70	0.61	2.84	2.22	1.42	
	76	0.27	1.27	1.01	0.74	

B. Bending Beam Rheometer (BBR)

Tests for creep stiffness using BBR were performed on thin beams of modified bitumen in order to investigate the low temperature thermal cracking capabilities of the material. In accordance with ASTM: D 6648, it has been proposed that the minimum m-value requirement should be 0.300 and the maximum stiffness criteria should be 300 MPa. During these tests, beams of bitumen measuring 125 millimeters in length, 12.5 millimeters in width, and 6.25 millimeters in thickness are immersed in a bath maintained at a constant temperature and maintained at the test temperature (beginning at -18 degrees Celsius) for thirty minutes. The deflection of the center point is then monitored constantly while a steady load of 100 grams is supplied to the rectangular beam, which is supported at both ends by stainless steel half-rounds spaced 102 millimeters apart. The creep stiffness, denoted by S, and the creep rate, denoted by m, of the binders are measured at a variety of loading durations ranging from 8 to 240 seconds.

Table 6 provides a comprehensive analysis that contrasts the BBR test results for samples of modified and unmodified bitumen. According to Table 6, the modified bitumen has a stiffness of 256, 280, and 363 MPa, and its m-value at -18 degrees Celsius is 0.326, 0.292, and 0.269, respectively, for TETA-Modified, BHETA-Modified bitumen, and SBS modified bitumen samples, respectively. This indicates that, with the exception of BHETA-modified bitumen, other PMB binders are consistently matched with the acceptable value limits at -18o degrees Celsius. As a consequence, TETA modified bitumen and SBS-Modified polymers have been found to be less prone to cracking at low temperatures.

Table 6: Bending Beam Rheometer of Neat and Modified Bitumen

Properties	VG-10 Bitumen		TETA-Modified Bitumen		BHETA Modified bitumen		SBS modified bitumen	
Temperature (in 0C)	Stiffness	m value	Stiffness	m value	Stiffness	m value	Stiffness	m value
-6	47	0.41	42	0.45	35	.50	85	0.38
-12	147	0.36	93	0.43	110	0.78	160	0.35
-18	395	0.29	255	0.32	280	0.28	362	0.27

C. Marshall Stability Test

The Marshall Stability test is used to determine the degree to which a compacted cylindrical bituminous pavement specimen is resistant to the plastic deformation of the material. Whenever a bituminous pavement specimen is tested at a standardized load and temperature its Marshall stability is measured as the amount of pressure it can withstand within a tightly compressed cylinder. This definition is based on the fact that the bituminous pavement specimen is compacted. The flow value is the amount of displacement a compressed cylinder of bituminous material experiences when confronted with a load up to its full capacity. This deformation takes place throughout the loading process. The Marshall strength and flow value for hot climates are specified to be 12 kilonewtons and 2.5 to 4 millimeters, respectively, in the Indian Road Congress Specification (IRC: SP-53). If the climate is cold, the Marshall Stability should be 10KN, and the flow should be between 2.5 and 4 mm. However, in locations with significant rainfall, the Marshall Stability should be 12KN, and the flow should be between 3.0 and 4.5 mm. As can be shown in Table 7, the Marshall Stability and flow value of every amended bitumen sample was found to be significantly improved. According to the findings, all of the formulations are capable of satisfying the Marshall Stability criterion in any and all imaginable environmental conditions, as required by IRC: 53-2010.

Table 7: Marshall Stability Test

Binder content	(Marshall Strength KN / Flow in mm) Compaction temperature:150º C			
	VG-10 Bitumen	TETA terephthalamide Modified bitumen	BHETA terephthalamide Modified bitumen	SBS modified bitumen
5%	12.80/2.43	16.66/3.48	12.3/2.41	17.4/2.86
5%	13.30/2.85	14.0/4.05	13.5/2.75	18.3/3
5%	13.15/3	15.29/3.67	11.50/2.34	17.8/2.97
Average Value	**13.08/2.76**	**15.32/3.73**	**13.94/2.50**	**17.83/2.94**
5.5%	14.28/2.46	16.85/4.51	15.2/3.89	18.6/2.86
5.5%	13.78/2.86	17.04/4.29	14.56/3.46	17.95/2.75
5.5%	13.64/3.28	17.25/3.67	14.38/3.46	18.9/3.15
Average Value	**13.90/2.87**	**17.05/4.16**	**14.71/3.60**	**18.48/2.92**
6%	14.54/3.58	19.50/4.59	16.54/4.85	22.45/3.95
6%	14.94/4.0	18.64/3.75	15.75/4.90	23.76/4.08
6%	15.05/3.96	19.67/3.95	16.67/5.65	23.80/4.15
Average Value	**14.84/3.85**	**19.27/4.10**	**16.32/5.13**	**23.37/4.06**

D. Hot Water Stripping Test

The Boiling Water Test, also known as ASTM D 3625-96 and having been reapproved in 2005, is a subjective test that estimates any negative effects that water infiltration may have on bituminous mixtures. Its primary purpose is to serve as a preliminary screening test for the bituminous mixes' ability to resist moisture.

During the course of the research, it was discovered that bitumen that had been doped with 2% PMB and produced finished in-situ responses of MDI and a TETA-based terephthalamide (which was derived from PET) exhibited excellent anti-strip properties, achieving a performance of more than 90% in hot water immersion tests (Fig. 2). In contrast to its TETA-based counterpart, the BHETA-based PMB did not demonstrate nearly as much potential for success.

VG-10 Bitumen   TETA-Modified Bitumen   BHETA Modified bitumen

Figure 2: Hot water stripping test

V. CONCLUSION

According to the findings of this study, reactive polymer modified bitumen binder has many benefits over traditional bitumen binder. These advantages have been shown. In addition, the finding suggests that the Marshall Stability of in-situ polymerized PMB was improved, and it was found to fulfill all of the parameters listed in IRC: 53-2010.

An evaluation of modified bitumen's creep stiffness using a bending beam rheometer (BBR) at room temperature revealed that the material's creep stiffness had been reduced while its m-value had been increased. Developed in-situ polymer modified binders showed much physical effect and fulfilled the specified characteristics down to -18 ° C.

In a similar vein, the results of a dynamic shear rheometer (DSR) demonstrate that the ratio of unaged polymer modified bitumen as well as RTFO aged polymer modified bitumen is greater than that of unmodified and SBS-based polymer modified bitumen binder. Additionally, it shows that the modified binder has exhibited favorable values since it is less rigid and more pliable when the temperature is lower.

Based on the findings of the current research, it seems that polymer modified bitumen binder (PMB) formed from PET waste may be an option for use in the building of roads for national highways.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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