Laboratory Evaluation On Asphalt Binders & Mixtures Containing Sugarcane Waste Molasses

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Abstract - Asphalt, a residue of petroleum distillation, is the most important binder in road construction around the world. Crude petroleum is a fossil fuel and mineral resource that will be depleted in the next 40 to 50 years. Rising energy prices and a strong world-wide demand for petroleum, as well as rising environmental toxins & pollution, have encouraged the development of alternative binders to modify or replace asphalt binders. To reduce carbon emissions, a non-toxic viscous fluid was added to the asphalt. One such material is molasses. Molasses, often known as black treacle, is a viscous fluid made from sugarcane or sugar beet that has been refined into sugar. The quantum of sugar, the extraction method, and the age of the plant all influence molasses.

The goal of this study is to determine how well an asphalt binder modified with sugarcane waste molasses performs in AC mixes. To achieve this goal, the effects of four sugarcane waste molasses levels of 5%, 10%, 15%, and 20% by asphalt weight as a substitute to base binder on the performance parameters of the binder and asphalt concrete combination were evaluated. Traditional binder tests were used to determine the conventional characteristics of the modified binder. And the mechanical characteristics of the sugarcane molasses modified binder in asphalt concrete mixes were also assessed utilizing tests such as Marshall stability as well as Moisture susceptibility test. The sugarcane molasses modified binder may considerably boost moisture damage resistance as well as Marshall characteristics such as load and flow rates of asphalt specimens, according to the results of the tests carried on asphalt mixtures. According to the results of laboratory tests, it is suggested that an optimum molasses content of 10 % by base asphalt weight should be employed as a base binder replacement in a Hot Mix Asphalt plant for the construction of flexible pavement.

***Key Words*: Asphalt base binder, Sugarcane waste molasses, Non-toxic viscous fluid, Optimum bitumen content, Tensile Strength Ratio,**

1. INTRODUCTION

The laboratory experiments are carried out on a series of bitumen replacement specimens ranging from 1% to 15%. The bitumen grade chosen has a viscosity VG 30. The behaviour of molasses modified bituminous mix was investigated, and it was discovered that the modified mix had better Marshall Characteristics. When molasses is added, the Marshall stability value increases for a brief period before decreasing, and the flow value likewise lowers. The OBC of the mix 4.7 percent. This test allows for a 13 percent molasses content substitution. This demonstrates that up to a certain amount of molasses may be substituted with bitumen. [1].

The purpose of this investigation was to see how adding three stages of cane molasses with varying percentage replacements affected the performance of the original bitumen (40/50). The percentage substitution of molasses mixed base bitumen with (0 percent, 5 percent, 10 percent, 15 percent, and 20 percent) was evaluated. The performance grade of the treated base bitumen (40/50) with 20% molasses-A, 10% molasses-B, and 5% molasses-C enhances the performance of the original bitumen by 28.12 percent, 15.79 percent, and 8.17 percent, respectively, according to test data. [2].

They performed laboratory studies on materials such as bitumen, aggregate, and bitumen with molasses, as well as strength and behaviour tests on bitumen and bitumen with molasses. The addition of 0.10 percent, 0.15 percent, or 0.20 percent molasses to the binder component increases the mixture's structural stability, enhancing rutting resistance and weight bearing capacity. [3].

This paper is for the modification of bitumen with sugarcane molasses, coconut shell charcoal, and a mixture of the two. The bitumen is modified with sugarcane molasses at various percentages ranging from 1% to 15%, and experiments were carried out for each percentage to determine the best proportion.

The bitumen is changed with coconut shell charcoal at various percentages, such as 5%, 10%, 15%, 20%, 25%, 30%, and 35%, and tests were undertaken for all of the percentages in order to determine the best proportion. The optimum molasses content for modified bitumen is 9%. Coconut shell charcoal should be used as modified bitumen at a rate of 20%. The ideal ratio of molasses and coconut shell charcoal in modified bitumen is 8% molasses and 4% charcoal. [4].

As the Molasses content increases, the solidity of HMA arranged by largely replacing black-top cover with Molasses decreases. The strength of the HMA is unaffected as the molasses level increases to 3%, but as the molasses content increases further, the solidity decreases by 1.5%, 17%, 22%, and 27% for molasses contents of 6%, 9 %, 12%, and 15%, respectively. Despite the fact that strength decreased as Molasses content increased, the dependability of blends with up to 11 percent Molasses content was within the Marshall Criteria for overwhelming traffic, i.e., above 8 KN. [5].

The bitumen samples are partially replaced with 5%, 10%, 15%, and 20% sugarcane molasses, and the results are compared with the addition of 21% quarry dust. Laboratory methods were used to study the conventional and mechanical characteristics of bitumen samples. By partially replacing bitumen with sugarcane molasses and quarry dust (up to 15% and 21% respectively), all of these qualities of bitumen gradually improve. [6].

The performance properties of asphalt binder treated with sugarcane waste molasses in AC mixes were examined in this work. They put varied percentages of sugarcane waste molasses contents of 5%, 10%, 15%, 20%, and 25% by asphalt weight to the test. The sugarcane molasses modified base binder greatly improved rutting resistance and moisture damage resistance in asphalt mixes, according to the testing results. They proposed that an ideal SWM concentration of 10% by base asphalt weight be used as an alternative to base binder in Hot Mix Asphalt based on the findings of the laboratory experiments. [7].

1.1 A Statement of Problem

The world has grown more concerned about global climate change, which is assumed to be produced by greenhouse gases, the most prominent of which is anthropogenic carbon dioxide, which is emitted into the atmosphere when fossil fuels are used. As a result, more ecologically friendly and non-toxic bitumen replacements have been introduced. Because of its outstanding non-polluting characteristics, molasses is employed in a wide range of industries. It has an advantage over other binding materials such as tar and lignin sulphonate in that it does not emit poisonous fumes when burned, making it more safer for the environment. Furthermore, because it is a liquid, it is simple to handle and incorporate into many industrial processes.

The current study is primarily concentrating on and conducting various laboratory experiments to investigate the effect of adding sugarcane waste molasses with varying percentage replacement on the performance of the original asphalt.

1.2 Objectives of Study

- ❖ To compare laboratory evaluation results and engineering characteristics and properties of asphalt binders and mixtures which containing sugarcane waste molasses.
- ❖ To determine the performance characteristics of asphalt binder and mixtures containing sugarcane waste molasses.
- ❖ To determine the optimum sugarcane waste molasses content to be added to the asphalt mix to achieve the desired strength.

2. MATERIALS USED

Fine & coarse aggregates, hot Mix asphalt binder, and sugarcane waste molasses were employed in this experiment.

2.1 Aggregates

The aggregates were obtained from the L.G BLUE METAL crusher in Tamilnadu. The figure-1 below depicts the combined gradation Percentage passing of the Aggregate by Job Mix Formula. The quantity of aggregates was accurately measured to ±0.1 grams in accordance with Indian Standards: 2386(Part 1)-1963.

2.2 Hot Mix Asphalt Binder

In this work, 60/70 penetration grade bitumen (VG-30) was utilized as a control binder is brought from Mangalore.

2.3 Sugarcane Waste Molasses

Sugarcane waste molasses was collected from a sugar factory in KM Doddi village, Mandya district, Karnataka state. Mandya is mostly recognized as a sugar & jaggery production district in the state of Karnataka. Sugar city (SAKKARE NAGARA IN KANNADA) is another name for it since sugarcane is a major crop. In this region, the inhabitants and farmers manufacture sugar and jaggery in their homes. As a result, waste molasses will be produced on a big scale in this region. Mandya is 100 kilometers from Bengaluru.

3. METHODOLOGY

Based on previous research and a review of the literature, the four sugarcane waste molasses concentrations of 5%, 10%, 15%, and 20% were chosen by asphalt weight.

In this project, we used bituminous concrete grade 2. (MORTH table 500-17).

First, typical tests were performed on coarse aggregates in accordance with IS:2386 (part1 & 2)-1963.

Then, the modified asphalt binders incorporating sugarcane waste molasses were subjected to traditional asphalt binder testing in accordance with IS:1203, 1205, 1206(part3), 1208, 1209.

To investigate the effectiveness of sugarcane waste molasses content as an alternative to asphalt binder in asphalt concrete mixes, hot mix asphalt mixture tests such as the Marshall Stability test and indirect tensile strength test were performed.

The results of all conventional tests on aggregates, traditional binder, and asphalt mixture tests on modified binder containing molasses are obtained and then analyzed.

3.1 Blending Proportion for bituminous concrete

In this Experimental investigation, combined aggregate gradation was employed as per figure-1.

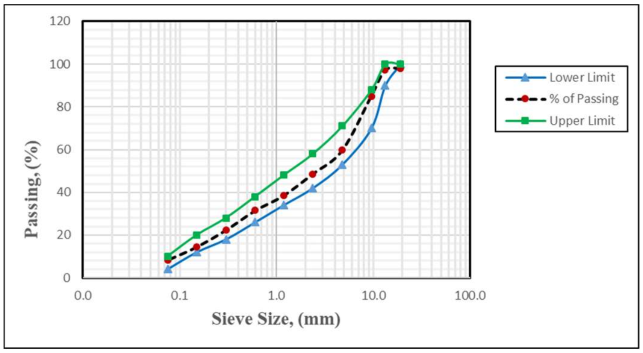

Figure -1: Blending proportion

3.1.1 Tests on Coarse Aggregate

The list of Tests conducted on the coarse aggregates as follows,

I. Specific gravity of aggregate
   a) Specific gravity.
   b) Apparent Specific gravity.
   c) Water absorption.
II. Impact test of aggregate.
III. Abrasion test of aggregate.
IV. Crushing value of aggregate.
V. Combined Index- (Flakiness & Elongation).

3.2 Tests on Asphalt Binder & Modified asphalt Binder

The following are the list of tests conducted on both Asphalt binder as well as Modified asphalt which containing sugarcane waste molasses.

I. Penetration Value.
II. Kinematic Viscosity.
III. Flash Point.
IV. Softening Point.
V. Ductility value.

3.3 Tests on asphalt concrete specimen.

There are majorly two asphalt mixture tests were conducted on the asphalt concrete specimen.

I. Marshall Stability Test.
II. Indirect tensile strength test.

3.3.1 Marshall Stability Test

3.3.1.1 Mix Design

Table -1: Marshall Mix Proportions.

PROPORTIONS		
Optimum binder content by weight mix	5.5 % by weight of mix	66 Gms
(16.0 - 7.0 mm)	42 % by weight of Aggregate	504 Gms
(7.0-3.0 mm)	10 % by weight of Aggregate	120 Gms
(3.0-0.0 mm)	46 % by weight of Aggregate	552 Gms
Cement Filler	2 % by weight of Aggregate	24 Gms

Table 1 depicts the proportions for marshall specimen preparation based on MORTH table 500-17, as well as the job mix formula restrictions.

Table –2: Combined Gradation Aggregate.

Combined Gradation Of Aggregate		
IS Sieve (mm)	Job Mix formula combined gradation Percentage passing	MORTH Specified Limits table 500-10
19	100	100
13.2	99.08	90-100
9.5	85.99	70-88
4.75	58.74	53-71
2.36	46.47	42-58
1.18	38.43	34-48
0.6	31.43	26-38
0.3	22.37	18-28
0.15	15.52	12-20
0.075	6.42	4-10

Table 2 depicts the job mix formula of combined gradation percentage passing as per MORTH (table 500-10) specified limits.

Table –3: Amount of molasses & asphalt content.

Amount of SWM & Asphalt Content Required for the Preparation of Marshall Specimen		
Percentage of SWM, (%)	Sugarcane waste Molasses, (Gms)	Asphalt Content, (Gms)
0	0	66
5	3.3	62.7
10	6.6	59.4
15	9.9	56.1
20	13.2	52.8

Table 3 Provides precise information about the molasses and asphalt content needed to prepare the specimen for the marshall stability test. As the % of molasses are added corresponding to that the asphalt content is reduced for the partially replacement of asphalt content.

In the laboratory, the base binder and molasses combination was made in a mixer by adding molasses to melted bitumen and mixing at 150±2 °C for around 10 minutes at a speed of 1600 rpm to obtain a well-homogenized blend. For the compacted samples for the conventional asphalt concrete mixture were undertaken at various binder amounts to identify the optimum bitumen content. Then for each percentage 3 moulds are prepared as per above mentioned mix design. Then marshall stability test is performed on the specimen in accordance with ASTM D 1559-76. Then the marshall load & flow values are note downed. Then Bulk Volume, Bulk Specific Gravity, % Air Voids, % VMA, % VFB, are determined using below equations mentioned. Then based on test results graphs are plotted.

- Marshall Stability Load, (KN) = Applied load in Division * Correction Factor * Proving Ring Factor.
- Bulk Volume (cc) = (Mass of Saturated Surface dry Specimen in Air) - (Mass of Specimen in water)
- Bulk Specific Gravity(Gmb) (gm/cc) = (Mass of Specimen in Air) / (Bulk Volume)
- % Air Voids = ((Max SG of loose Mixture)-Bulk SG Specimen)) / (Max SG of Loose Mixture) *100
- % Voids in Mineral Aggregate = 100 - ((Bulk SG of Specimen * Percentage of Aggregates)) / (Bulk SG of Aggregate)
- % Void Filled with Bitumen = 100 * ((% Voids in Mineral Aggregate-% Air Voids)) / (% Voids in Mineral Aggregate)

3.3.2 Indirect tensile strength test.

Tensile Strength Ratio is used to assess the moisture susceptibility of a hot mix asphalt mixture. The marshall specimen was subjected to an indirect tensile strength test in order to compute the tensile strength ratio in accordance with MORTH (table500-13) and AASHTO T283.

The indirect tensile strength test has the same mix design as the marshall mix design. Eight moulds are created for each %. Four of the moulds are kept conditioned, while the remaining four are unconditioned. The dry condition tensile strength of the first set of compacted samples was measured in an environmental chamber at 25 °C for two hours. The second set of compacted samples was placed in a 60-degree-Celsius water bath for 24 hours before conditioning in a 25-degree- Celsius water bath for two hours. The dry and wet specimens were tested for indirect tensile strength at a displacement rate of 50 mm/min at a temperature of 25 °C. Then tensile strength ratio is determined using below mentioned equation,

Indirect TSR = (Average Indirect Tensile Strength Values of Conditioned Specimens) / (Average Indirect Tensile Strength Values of Unconditioned Specimens) *100

ITS of Specimen (2000*P)/(π*D*h)

Where, P = Applied Load @ Failure, (KN).

D = Diameter of Specimen, (CM).

t = Height of the Specimen, (CM).

1 Division = 61.53 Newton's /6.27 Kilograms.

4. RESULTS AND DISCUSSION

4.1 Laboratory results of Coarse Aggregates

The following physical properties of aggregates are determined using different tests for evaluating the suitability of coarse aggregates in road construction

Table –4: laboratory results for coarse aggregates.

SL NO	NAME OF THE TESTS	TEST RESULTS
1	SPECIFIC GRAVITY	2.71
2	APPARENT SPECIFIC GRAVITY	2.708
3	WATER ABSORPTION	0.10%
4	IMPACT TEST	23.38%
5	ABRASION TEST	13.58%
6	CRUSHING TEST	16.90%
7	COMBINED INDEX	26%

As reported in Table 4, The aggregates meet the criteria for specific gravity & apparent specific gravity [2.5-3], And water absorption [0.1-2%], impact value [<35%], abrasion value [<30%], aggregate crushing value [<30%], combined index value [<35%] as per IS 2386-(part1,3,4,5). Therefore, the laboratory test results are satisfactory for road construction.

4.2 Basic Test Results of Asphalt with SWM

The following properties of asphalt with sugarcane waste molasses are determined using different tests for evaluating the suitability of bitumen in road construction.

Table –5: laboratory results of Asphalt & Asphalt with SWM.

Sl No	Name of the Test	Sugarcane waste Molasses, (%)				
		0%	5%	10%	15%	20%
1	Penetration Value,(1/10mm)	62.4	51.2	46.8	45.6	45.2
2	Kinematic Viscosity, (Cst)	351.017	382.65	383.42	383.67	383.92
3	Flash point,(°C)	320	290	295	295	295
4	Softening point, (°C)	50.5	51.5	51.9	52	52.6
5	Ductility Value, (cm)	110	114	118	125	128

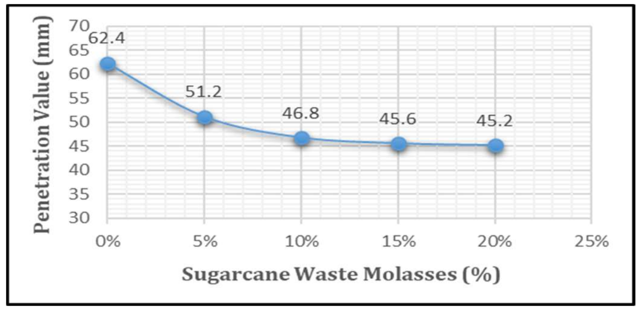

Figure –2: Penetration Value.

The penetration values decrease in general as the molasses content increases. The drop in penetration value was fairly significant between 10% and 20% changes.

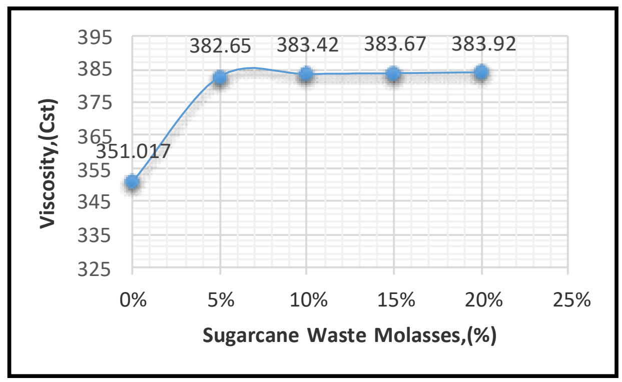

Figure –3: Kinematic Viscosity

With increasing molasses content, viscosity of the modified asphalt with molasses is also increased. The viscosity data show that the viscosity value increases dramatically with 5% molasses treated asphalt, but there is no significant difference between the viscosity of 5%, 10%, 15%, and 20% molasses modified asphalt.

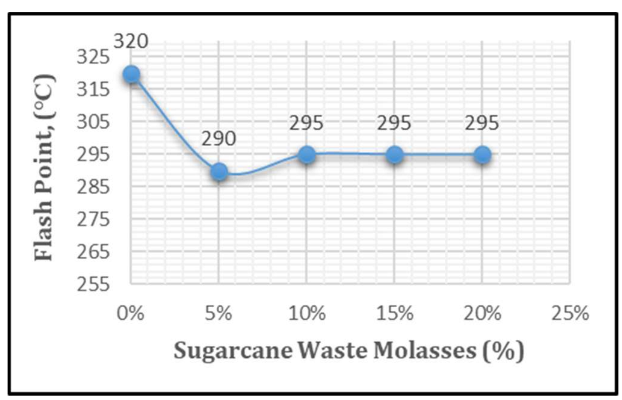

Figure –4: Flash Point.

It is the lowest temperature at which a bituminous material's vapour quickly catches fire in the form of a flash under specific test circumstances. In comparison to base asphalt, the fire point of molasses flashes at quickly at 290°C.

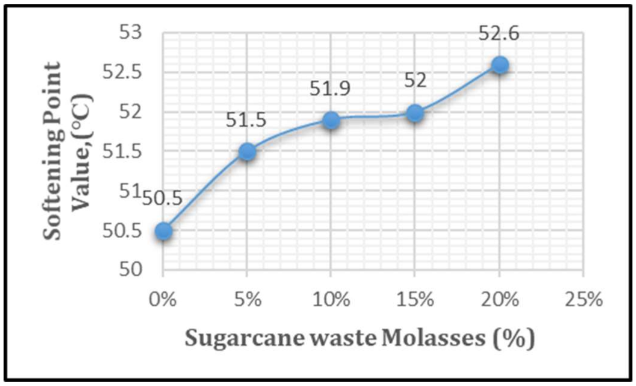

Figure –5: Softening Point.

When the molasses concentration of the modified binder was increased in comparison to the base asphalt, the softening point temperature of the modified binder increased. This tendency indicates that the changed binders are stiffer and have reduced temperature susceptibility, which are crucial properties, especially when there is substantial variation in high temperature circumstances.

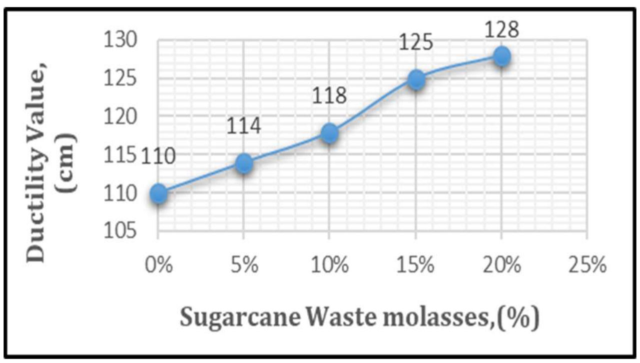

Figure –6: Ductility Value.

The ductility findings of the molasses modified binder are greater than 100 cm, which satisfied the required limit for binders.

4.3 Test Results of Hot Mix Modified Asphalt with Sugarcane Waste Molasses

4.3.1 Marshall stability [optimum bitumen content]

The below table shows marshall properties of conventional asphalt.

Table –6: Optimum bitumen content.

Asphalt Content, (%)	Stability, (kn)	Flow, (mm)	Density, (gm/cc)	AV, (%)	VMA, (%)	VFB, (%)
4.5	11.20	1.8	2.385	6.414	16.888	62.022
5	11.70	2.3	2.406	5.425	16.581	67.281
5.5	11.90	2.8	2.420	4.150	16.529	74.893
6	10.80	3.5	2.410	3.906	17.320	77.448
6.5	10.20	4.3	2.407	2.367	17.875	86.759

The optimum binder content 5.5% was determined by calculating the average value of the bitumen content that corresponds to maximal stability and maximal bulk weight & also for average value of bitumen content corresponds to 4% of air voids. Based on the optimum bitumen content of traditional asphalt, subsequent tests on asphalt modified using sugarcane waste molasses are being done.

4.3.2 Marshall stability [optimum sugarcane molasses content]

The following are the test results for optimum sugarcane waste molasses content:

Table –7: Optimum sugarcane waste molasses content.

SWM Content(%)	Stability, (kn)	Flow, (mm)	Density, (gm/cc)	AV, (%)	VMA, (%)	VFB, (%)
0	11.90	2.8	2.4202	4.150	16.529	74.893
5	11.40	3.2	2.4245	4.130	16.380	74.925
10	11.20	3.6	2.4270	4.111	16.297	74.990
15	9.60	4.0	2.4220	4.010	16.985	75.230
20	8.70	4.5	2.4109	3.901	17.398	75.652

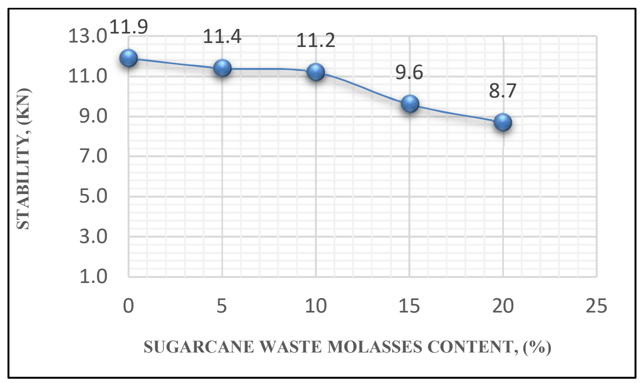

Figure –7: Stability vs SWM.

The marshall stability value of molasses that replaces 5%, 10%, 15%, and 20% of the total binder weight has been slightly reduced. The marshall stability of molasses modified asphalt mixes is 11.40kn, 11.20 kn, 9.60 kn, and 8.70 kn for molasses concentrations of 5%, 10%, 15%, and 20%, respectively, which is 5%, 7%, 23%, and 32% lower than that of normal asphalt concrete mixture of 11.9 kn. The drop in marshall stability readings might be related to the aggregate adhesion ability in asphalt concrete mixes. According to ASTM D6927-06, the marshall stability value must be more than 8.0 kn to achieve the minimum standard for road pavement. As a result, SWM substituting 5%, 10%, and 15%, 20% of the base binder may be utilised to change the base binder in hot mix asphalt mixes. For the optimum sugarcane waste molasses content, the maximum stability value corresponding to SWM% is considered just before the stability value decreases. That is 11.40 KN at 5%.

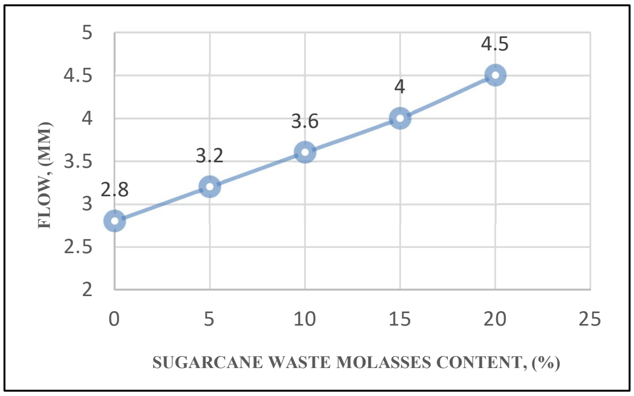

Figure –8: Flow vs SWM.

The flow value is the overall deformation of the Marshall test specimen at maximum load, measured in millimeters. The maximum flow value is 4.5mm at 20% & the minimum flow value is 2.8 at 0%. According to MORTH table 500-11, the flow value for modified bitumen in hot temperature conditions should be 2.5-4. The flow values determined in the laboratory are within the required range. Low flow values are undesirable because pavements made with such mixtures are prone to cracking owing to large movement loads. For the optimum sugarcane molasses content, the flow is considered at the midpoint of the flow value chart that is 3.6 @ 10%.

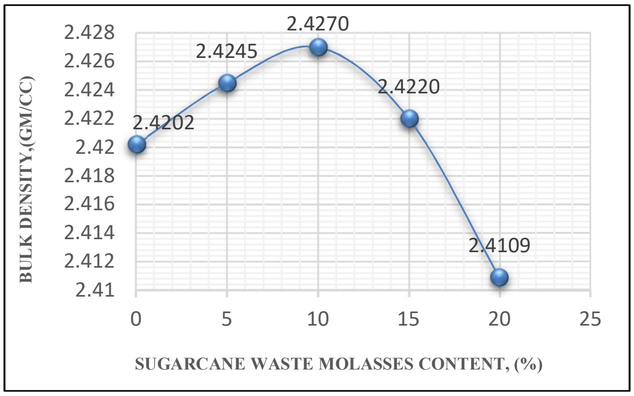

Figure –9: Bulk Density vs SWM.

As indicated in the figure above, the partial substitution of molasses has affected the unit weight of asphalt concrete mixtures. The overall trend demonstrates that as the molasses content increases, the bulk specific gravity drops. At 10% swm, the highest bulk density is 2.4270 g/cc, while the lowest bulk density is 2.4109 g/cc at 20%. High bulk density indicates compaction of specimen & low porosity. For the optimum sugarcane waste molasses content, the maximum bulk density value corresponding to SWM% is considered just before the density value decreases. That is 2.4270 gm/cc at 10%.

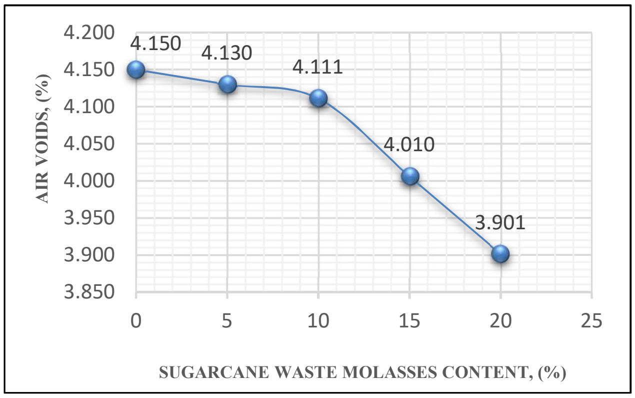

Figure –10: Air Voids vs SWM.

For the optimum sugarcane waste molasses content, the air voids exactly selected at 4% corresponding to sugarcane waste molasses content i.e., 15%. If we choose an optimum bitumen content less than 4%, the pavement will rut and will not fulfill the VFB requirements. If we choose a 3% OBC, there will be reduced voids (1%) or no voids after running traffic. All of this causes rutting and bitumen to drain off the surface in summer season. On the other hand, if we choose OBC with more than 5% air voids, the pavement will be permeable to air and water even after running continuous traffic. The pavement will lose its durability, and as a result of this, a pothole in the pavement may form or destroy the entire pavement.

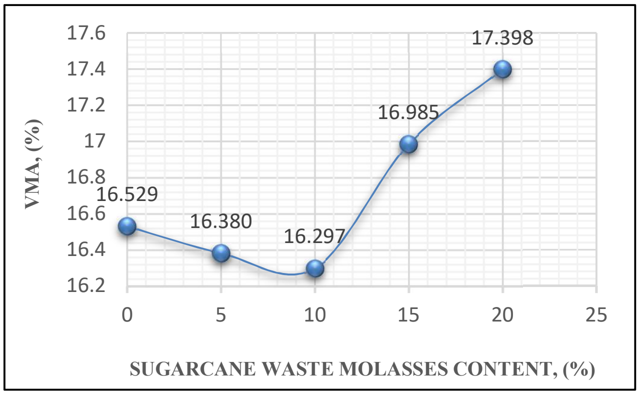

Figure –11: VMA vs SWM.

VMA denotes the volume of voids in aggregates and is the sum of air voids and bitumen volume. VMA is essential to understand because it indicates the space available to accommodate the effective volume of asphalt and the volume of air voids required in the mixture. As a result, a minimum VMA is required to establish an acceptable asphalt film thickness, which results in a long-lasting asphalt pavement. The graph above shows the minimal value of VMA at 10% of swm.

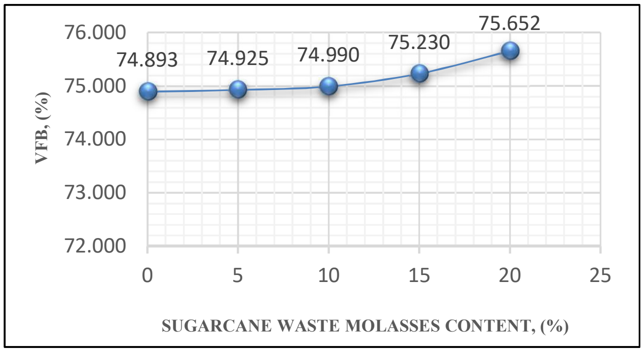

Figure -12: VFB vs SWM.

As seen in the graph above, the VFB of the mixtures increases as the molasses content increases. The cause for this rise is due to an decrease in VMA and a reduction in air voids when molasses content rises. For the optimum sugarcane molasses content, the VFB is considered at the midpoint of the VFB graph that is 74.990 @ 10%.

4.3.3 Indirect tensile strength test

The following are the indirect tensile strength values of modified asphalt with sugarcane waste molasses content at dry and wet conditions and also Tensile strength ratio:

Table -8: ITS @ Dry Condition.

ITS Dry Condition	0 % SWM	5% SWM	10% SWM	15% SWM	20% SWM
Sample 1	1950.660	2173.992	2448.184	2181.823	1802.790
Sample 2	1938.952	2166.162	2467.729	2224.922	1763.599
Sample 3	1966.391	2193.537	2499.114	2236.636	1783.194
Sample 4	2016.811	2205.314	2385.477	2146.554	1700.893
Average load,(K.pa)	**1968.203**	**2184.751**	**2450.126**	**2197.483**	**1762.619**

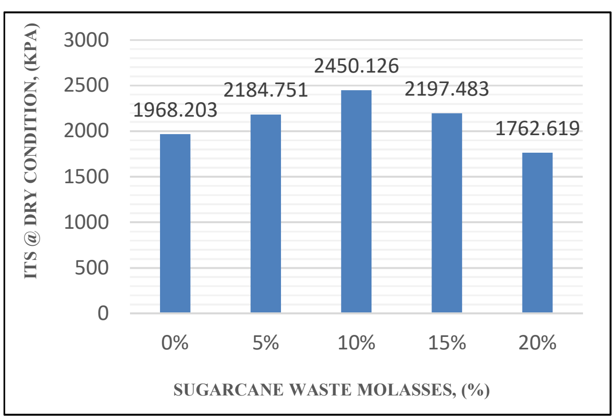

Figure -13: ITS @ Dry Condition vs SWM

Table -9: ITS @ Wet Condition.

ITS Wet Condition	0 % SWM	5% SWM	10% SWM	15% SWM	20% SWM
Sample 1	1609.880	1915.461	2307.173	1938.952	1426.555
Sample 2	1598.170	1903.684	2330.664	1978.104	1371.688
Sample 3	1637.322	1931.122	2346.325	1997.712	1410.879
Sample 4	1688.251	1935.005	2224.922	1904.002	1356.011
Average load,(K.pa)	**1633.405**	**1921.318**	**2302.271**	**1954.692**	**1391.283**

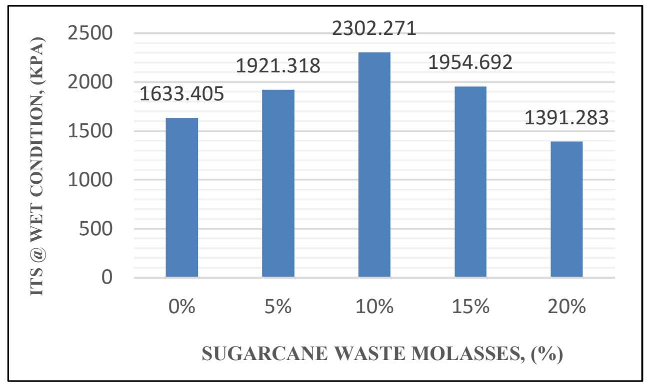

Figure -14: ITS @ Wet Condition vs SWM

Table-10: Tensile Strength Ratio

Sugarcane Waste Molasses, (%)	Tensile Strength Ratio
0%	82.989
5%	87.942
10%	93.965
15%	88.951
20%	78.933

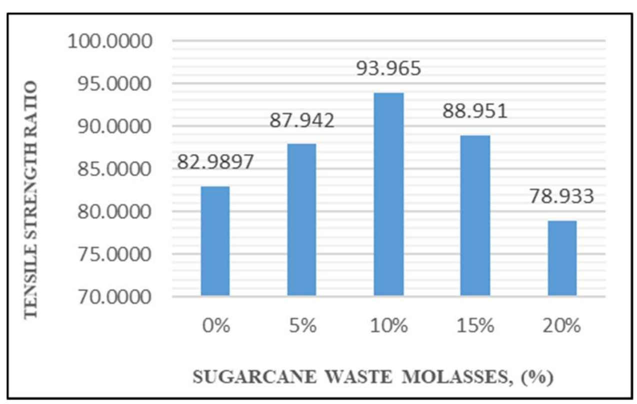

Figure -15: Tensile Strength Ratio

The moisture susceptibility may be determined using the tensile strength ratio. When testing moisture resistance, TSR alone was determined to be insufficient. To evaluate the moisture damage resistance of asphalt mixtures, it is recommended to test both TSR and wet ITS strength at the same time. Table 8 Shows indirect strength values at dry condition & Table 9 shows indirect strength values at wet conditions.

The indirect tensile strength values at both dry & wet conditions are maximum at 10% corresponding to sugarcane waste molasses.

Tensile strength ratio values are 87.942 percent, 93.965 percent, and 88.951 percent for sugarcane waste molasses contents of 5%, 10%, and 15%, respectively, which is 5%, 11%, and 6% higher than those of the typical asphalt mixture (82.989 percent). On the other hand, tensile strength values of 20% sugarcane waste molasses, are lower than those of the control asphalt concrete mixture. The drop in tensile strength values of these modified mixes might be attributed to their reduced adhesion ability under saturated conditions. It was found that replacing more than 20% of sugarcane waste molasses with asphalt binder was insufficient to achieve the minimum criterion of 80%.

This modified binder with 10% sugarcane waste molasses content seemed to have the maximum coating ability with aggregates in all modified mixes. As a result, in terms of moisture-damaged resistance, the optimum sugarcane waste molasses content of 10% may be employed as a replacement to the base binder in asphalt concrete mixes.

5. CONCLUSIONS

The current study was primarily concerned with the utilization of sugarcane waste molasses as an alternative to asphalt binder in asphalt mixtures. The following conclusions are reached based on the findings of experimental testing:

1]. The use of sugarcane waste molasses as a replacement to base binders may greatly increase binder penetration resistance, softening temperature, and kinematic viscosity, which is advantageous to improving the high-temperature performance of the modified asphalt binders and asphalt concrete mixtures.

2]. The overall stability value exceeds 8.0 kn for all percentages and meets the minimum criteria for road pavement. and the highest stability value for sugarcane waste molasses is 11.40 KN.

3]. The results of moisture susceptibility tests revealed that using sugarcane waste molasses as an alternative to base binders can greatly enhance the moisture susceptibility of the mixtures. However, replacing 20% of the with asphalt binder reduces the tensile strength value. It was determined that the modified binder with 10% sugarcane waste molasses content has the maximum tensile strength ratio value.

4]. According to the results of the research of the behavior of molasses modified asphalt, the asphalt can be modified with sugarcane waste molasses up to an optimum proportion of 10 percent. This optimum percentage results in a significant rise in the values of bitumen's fundamental attributes. Furthermore, it significantly increases the moisture-damaged resistance of asphalt concrete mixtures.

5]. It is recommended that the further (SEM & EDS) experimental investigations should be performed for sugarcane waste molasses and sugarcane waste molasses with asphalt. One of the most prevalent technologies for examining the microstructure and morphology of materials & chemical characterization and element analysis of materials is the scanning electron microscope (SEM). & Energy-dispersive X-ray spectroscopy (EDS).

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