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UTILIZING THE MODIFIED BITUMEN FOR ROAD CONSTRUCTION

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ABSTRACT

Bituminous Concrete (BC), a composite material used in flexible pavement construction, is mostly utilized in parking lots, airports, road covering projects. It is made up of mineral aggregate and asphalt or bitumen (used as a binder), which are combined, spread out in layers,& then compacted.

These days, the constant increase in heavy commercial vehicle traffic and the wide range of daily and seasonal temperatures place us in a difficult position where we must come up with some ideas for improving the pavement's quality and characteristics by implementing the necessary changes that will meet both strength and cost considerations. Plastics are pervasive in modern life and are expanding quickly everywhere, especially in emerging nations like India. The handling of these solid wastes is a significant challenge to society because they are not biodegradable. It has been discovered that bitumen can be effectively modified with low density polyethylene.

As specified by the IRC Code, mixes with a chosen aggregate grading are prepared using different percentages of polythene. Marshall samples of BC mixtures with and without polymer are prepared in order to investigate the role of polythene in the mix for different engineering qualities. Optimal polythene concentration for the specified bitumen grade (80/100) is determined by Marshall qualities such stability, flow value, unit weight, and air spaces.

Key Words: Bituminous Concrete (BC), Plastic waste, Aggregate, Marshall stability, Flow value, Optimum Polythene Content

INTRODUCTION

The paving industry makes extensive use of bituminous binders. There are various layers in a pavement. Bitumen and aggregate are bituminous concrete's (BC) primary ingredients. All hard surfaced pavement types are often divided into two groups: flexible and rigid. **Flexible Pavement:** Flexible pavement is a type of road surface that may undergo some form changes without breaking. For instance, water-bound macadam pavement, bituminous pavement, and gravel pavement.

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Rigid Pavement: Rigid pavement is a type of road surface that is incapable of changing shape without breaking. Cement concrete pavement, for instance.

CONCERN OF PLASTIC WASTE

The performance of bituminous mix pavements is significantly impacted by everyday wear and tear, tyre pressure changes, wheel loads, and environmental changes. Therefore, given the current situation, any modification to the pavement's properties is absolutely necessary.

Due to their chemical linkages, plastics are resistant to normal natural processes of disintegration and are both long-lasting and non-biodegradable. Approximately one billion tons of plastic have been thrown away since the 1950s, and they may survive for hundreds or perhaps thousands of years. Fish and many other aquatic species die as a result of the plastic becoming mixed with water, failing to break down, and taking the shape of tiny pallets, which they mistake for food.

Since plastic materials are already a commonplace part of our everyday lives, there is a vast amount of plastic waste available nowadays. They are either dumped over a land area or combined with municipal solid waste.

They may currently be disposed of by burning or land filling if they are not recycled. The ecosystem is significantly impacted by both processes. They damage the air if they are burned, and they pollute the soil and water if they are discarded. In these situations, these plastic waste materials need to be put to another use.

PLASTIC OR POLYMER'S FUNCTION IN PAVEMENT

In order to address the issues brought on by the sharp rise in wheel loads and the shifting climate, BC modification with a synthetic polymer binder may be feasible. One way to increase the pavement's fatigue life and lessen rutting and thermal cracking is by polymer modification.

When asphalt and polymer are combined, a multiphase system with a lot of asphalt that is not absorbed by the polymer is created. As a result, a more internal complicated structure forms, increasing the mix's viscosity.

Benefits:

1.Cut the amount of bitumen required by about Ten percent.
2. Create an environmentally friendly technology.
3. Increases in the roads' fatigue life.
4. Utilize a larger proportion of plastic waste.
5. Smoke absorbent absorbs the gasses emitted during traffic situations.

Drawback :

1. the toxic material in the mixed waste would begin to seep out.
2. However, HCl gas will undoubtedly be released when chlorine is present.

Objectives:

The following goals have been met by the objective study:

1. To enhance the BC mix design's volumetric characteristics.
2. In bituminous mixtures, to use discarded plastic.

3. To add fly ash to bituminous mixtures as a filler.
4. To assess the BC mix design's performance in the lab.
5. To offer a road that is environmentally beneficial.

SUPPLIES USED IN THE CURRENT STUDY

Aggregates:

The granular component of bituminous concrete mixtures, aggregate makes up 90–95% of the combination weight and is responsible for the majority of the mixture's strength and load-bearing properties. Therefore, to guarantee a decent pavement, the aggregates' quality and physical characteristics should be managed.

There are two kinds of aggregates such as

a) fine aggregate (FA)

b) coarse aggregate (CA).

CA, or coarse aggregate

The 4.75 mm IS aggregates that were kept Coarse aggregates are what a sieve is. Crushed rock with an angular shape that is free of dust, clay, vegetation, and organic materials should be used as coarse aggregate.

Fine Aggregate (FA)

Clean screened quarry dusts should be used as fine aggregate. It must be devoid of organic matter, plants, clay, and loam. A 0.075 mm IS sieve was used to hold the fine aggregates, which were made up of stone crusher dusts, that were collected from a nearby crusher with fractions exceeding 4.75 mm. It stiffens the binder and fills the spaces in the coarse aggregate.

Bitumen:

In this study, asphalt binder 80/100 is utilized. In bituminous mixtures, bitumen serves as a binding agent for the aggregates, fines, and stabilizers. Since bitumen demonstrates both viscous and elastic qualities at the typical pavement temperature, it must be regarded as a visco-elastic material. It exhibits the characteristics of an elastic material at low temperatures and a viscous fluid at high temperatures. In this study, asphalt binder VG10 is utilized. The bitumen grade used in pavements should be chosen based on prior performance and climatic circumstances. It provides impermeability, fills in the gaps, and causes particle adhesion.

Filler:

Fly ash or stone dust are two possible fillers.

Filler is the term for aggregate that passes through a 0.075 mm IS sieve. It provides permeability, stiffens the binder, and fills in the gaps. Fly ash and stone dust were utilized as filler materials. 2.10 is the specific gravity.

Polythene Waste :

To improve the binding properties, stabilizing chemicals are added to the mixture. Nowadays, cellulose, mineral, polyester, and polypropylene are frequently utilized fibers. Polyethylene is utilized as a stabilizing addition in this study to enhance pavement performance characteristics.

Table 1: Characteristics of the polythene utilized in this investigation

S. NO	PROPERTIES	RESULT OBTAINED
1	SPECIFIC GRAVITY	0.65
2	MELTING POINT (^{0}C)	250-260
3	SIZE	3mm x 30mm

METHODOLOGY:

- Segregation.
- Cleaning Process.
- Shredding and mixing of bituminous
- Laying of bituminous mix

Segregation:

It is necessary to segregate plastic waste from other material that is gathered from other sources, such as dump sites, garbage trucks, and roadways.

Cleaning Process

Plastic waste is sorted, cleaned, and de-dusted as needed.

Bituminous Shredding and Mixing:

Various plastic wastes are combined, chopped into tiny pieces, and then shred with a shredding machine. In a central mixing facility, the aggregate is heated to 160 degrees Celsius. Likewise, bituminous is heated to 160 degrees Celsius.

Bituminous Mix Laying:

Hot bitumen is combined with aggregate coated with plastic trash, and the resulting mixture is utilized to build roads. The temperature range for laying roads is 1100 to 1200 degrees Celsius. The roller in operation has a capacity of eight tons.

Experimental Programme :

Other experiments on bitumen and aggregate should also be conducted as part of the experimental effort, in addition to the Marshall Test. The primary goal of testing bitumen and aggregate is to determine whether the test results fall within the range specified by IRC III-2009 codes.

Table 2: Aggregate properties used in this investigation

S. NO	PROPERTIES TEST	TEST RESULT	MORTH SPECIFICATION
1	Particular gravity Fine aggregate coarse aggregate	 2.74 2.81	 2.5-3.0 2.5-3.0
2	Test of Aggregate Impact Value	10.72	Max. 27%
3	Test of aggregate crushing value	14.55	Max.30%
4	Test of Los Angeles Abrasion Value	23.99	Max.30%

Table 3: Bitumen properties used in this investigation

S. NO	PROPERTIES TESTED	TEST RESULT	RANGE
1	Test of ductility at 27 °C (5 cm/minute pull) cm	82	75min
2	Test for softening point, ^{0}C (Ring & Ball Equipment)	54	40 ^{O}C min.
3	Penetration: 25 ^{0}C, 5sec, 100gm	94	80-100mm
4	27 ^{O}C specific gravity test	1.04	0.99min.

Marshall Test

- The necessary amounts of filler, fine aggregate, and coarse aggregate were taken in a pan to prepare the bituminous mix. For two hours, the pan was preheated in the oven at room temperature ,or 175 degrees Celsius. This is due to the fact that bitumen and aggregate must be combined while hot.
- Prior to mixing, the bitumen was heated to its melting point side by side. After being cleaned, the compaction mold assembly is placed in the oven to be preheated to between 100 and 145°C.
- Weighed out and stored separately in a pan was the necessary quantity of shredded pla stic.
- After adding the plastic, the aggregate was well mixed for two minutes.
- After adding the bitumen in the necessary percentage, the mixture is agitated for 15 to 20 minutes to ensure that the color is consistent throughout.
- The entire mixture is moved to a casting mold after mixing.
- The Marshall Compaction pedestal holds the mold. The sample is inverted and compacted in the opposite face using the same number of blows as the mix, which is compressed using 75 hammer blows.
- Following compaction, the mold-containing sample is allowed to cool for a few hours. After being removed from the mold, the sample is left at room temperature for a full day.
- Prior to testing, the sample is maintained in a water bath at a temperature of 60 °C for a duration of 20 to 30 minutes.
- The mass of the sample in air and its submerged weight are utilized to determine the density of the specimen, facilitating the calculation of its void properties.

Mix Volumetric

Before the Marshall test, the volumetric parameters from the Marshall samples must be verified. The following formulas would be used to calculate the absorbed bitumen content (Pab) and volumetric characteristics like VMA, VA, VFB, etc. Often overlooked in the formulation of bituminous mixes, the absorbed bitumen is a crucial characteristic (Chakraborty & Das, 2005).

The parameters of interest are the bulk specific gravity of the mix (Gm), the theoretical specific gravity (Gt), the percentage of bitumen volume (Vb), the percentage of air voids (Vv), the percentage of voids in mixed aggregate (VMA), and the percentage of voids filled with bitumen (VBF).

Theoretical specific gravity of the mix Gt

The specific gravity in theory Gt, or specific gravity without air voids, can be calculated using:

$$\mathbf{gt} = \frac{\mathbf{w1} + \mathbf{w2} + \mathbf{w3} + \mathbf{wb}}{\frac{\mathbf{w1}}{\mathbf{G1}} + \frac{\mathbf{w2}}{\mathbf{G2}} + \frac{\mathbf{w3}}{\mathbf{G3}} + \frac{\mathbf{wb}}{\mathbf{Gb}}}$$

where

- ✓ W1 represents the total weight of coarse aggregate
- ✓ W2 represents the total weight of fine aggregate
- ✓ W3 represents the total weight of filler
- ✓ Wb represents the weight of bitumen in the entire mix.
- ✓ Gb is the apparent specific gravity of bitumen
- ✓ G1 is the apparent specific gravity of coarse aggregate
- ✓ G2 is the apparent specific gravity of fine aggregate
- ✓ G3 is the apparent specific gravity of filler.

Bulk specific gravity of mix (Gm)

The mix's real specific gravity or bulk specific gravity Gm, or specific gravity with air gaps taken into account, is determined by

$$\mathbf{Gm} = \frac{\mathbf{Wm}}{\mathbf{Wm} - \mathbf{Ww}}$$

where,

Wm is the weight of mix in air

Ww is the weight of mix in water.

Air voids percent (Vv)

The percentage of air voids by volume in the specimen is known as air voids Vv, and it may be calculated using:

$$\mathrm{Vv} = \frac{\mathrm{Gt} - \mathrm{Gm}}{\mathrm{Gt}} \times 100$$

Percent volume of bitumen Vb

The volume of bitumen Vb is the percent of volume of bitumen to the total volume and given by

$$\mathbf{Vb} = \frac{\mathbf{Wb}/_{\mathbf{Gb}}}{(\mathbf{W1} + \mathbf{W2} + \mathbf{W3} + \mathbf{Wb})/_{\mathbf{GM}}}$$

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where

- ✓ W1 represents the weight of coarse aggregate,
- ✓ W2 represents the weight of fine aggregate,
- ✓ W3 represents the weight of filler, Wb represents the weight of bitumen, Gb represents the bitumen's apparent specific gravity

Gm represents the mix's bulk specific gravity.

Voids in Mineral Aggregate

It is the amount of intergranular void space—which comprises the effective bitumen content and air voids—between the uncoated aggregate particles of a compacted paving mixture. VMA is given as a percentage of the compacted paving mixture's overall volume.

$VMA = V_{v} + V_{B}$

Where, Vv= Air voids (%)

Vb= Volume of bitumen

Voids Filled with Bitumen

It is the proportion of VMA that is made up of bitumen that works.

$$\mathbf{VFB = \frac{Vb}{VMA} \times 100}$$

Where,

Vb= Volume of bitumen

VMA= Voids in mineral aggregate.

ANALYSIS OF RESULTS:

A total of five curves were plotted. For example...

POLYTHENE CONTENT %	MEAN VMA %	MEAN VA %	MEAN VFB %	MEAN S (KN)	MEAN F (MM)
0	23.52	11.69	47.84	13.08	3.25
1	20.98	9.61	39.85	13.51	2.95
2	25.85	13.96	12.25	13.98	2.58
3	16.01	4.77	67.98	14.49	2.15
4	14.88	4.02	69.25	17.39	2.34
5	9.15	1.55	82.62	16.87	2.38

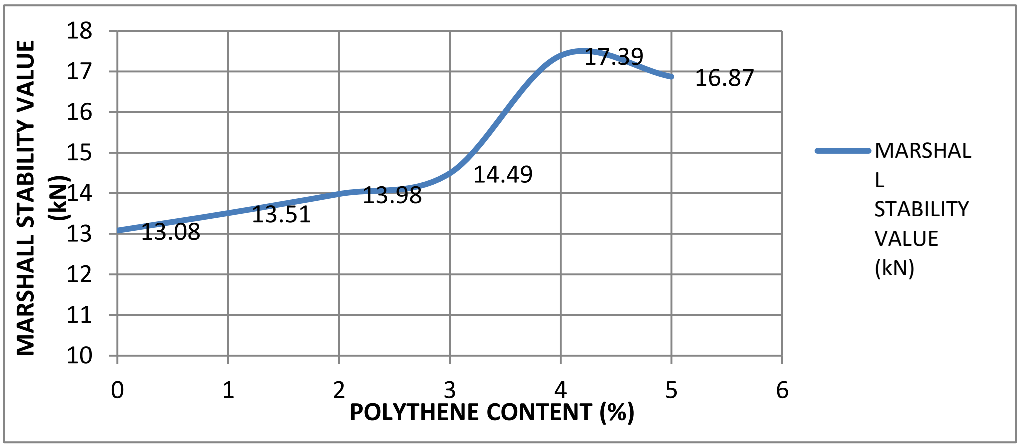

Fig.1 : Marshall Stability Value vs. Polythene content

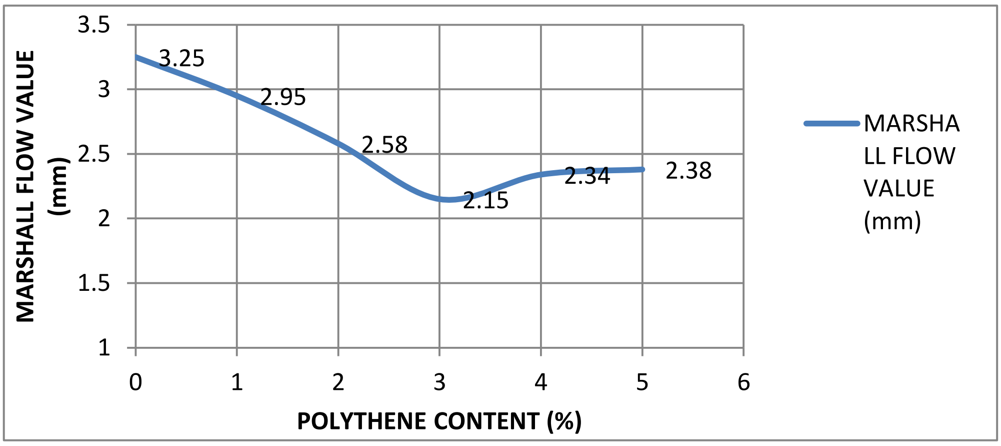

Fig.2: Flow Value vs. Polythene Content

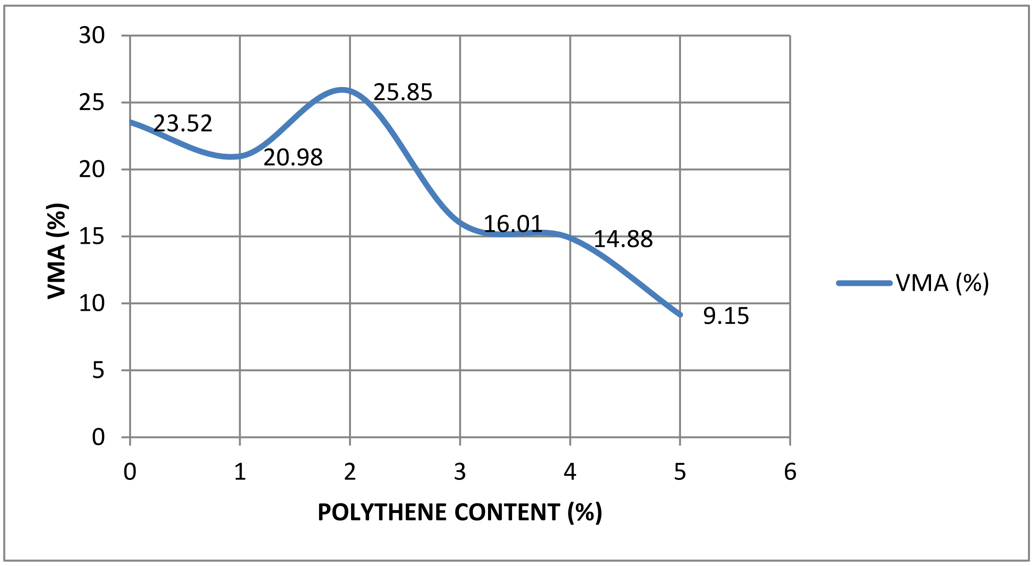

Fig.3: VMA vs. polythene content

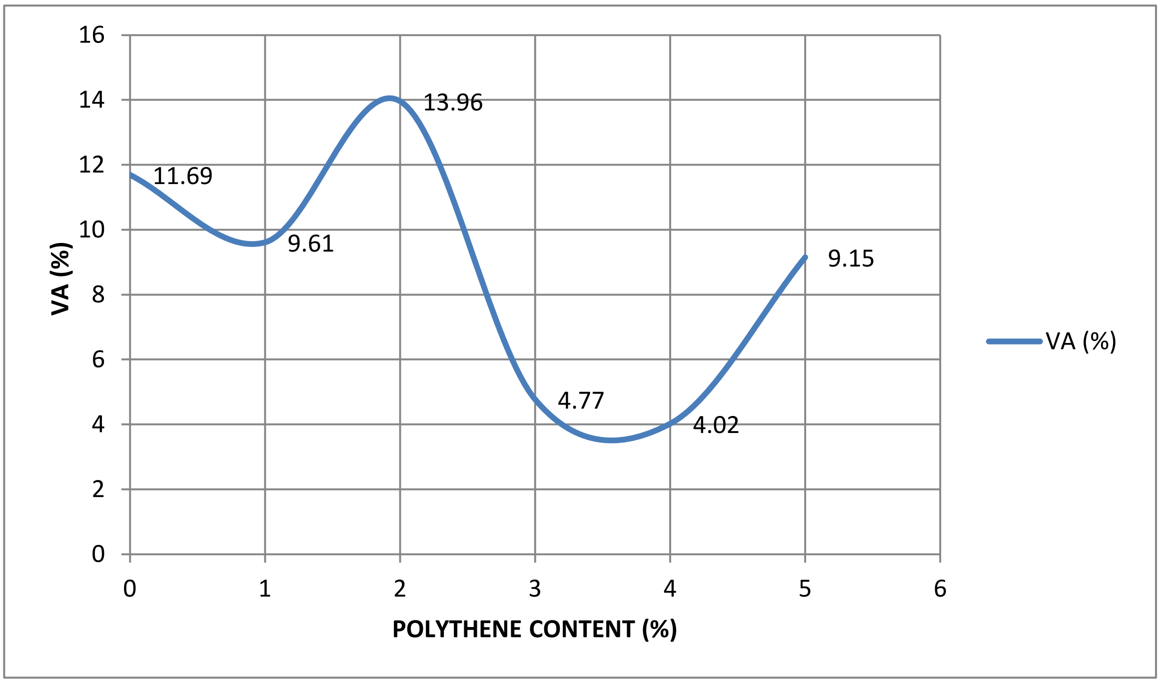

Fig.4: VA vs. polythene content

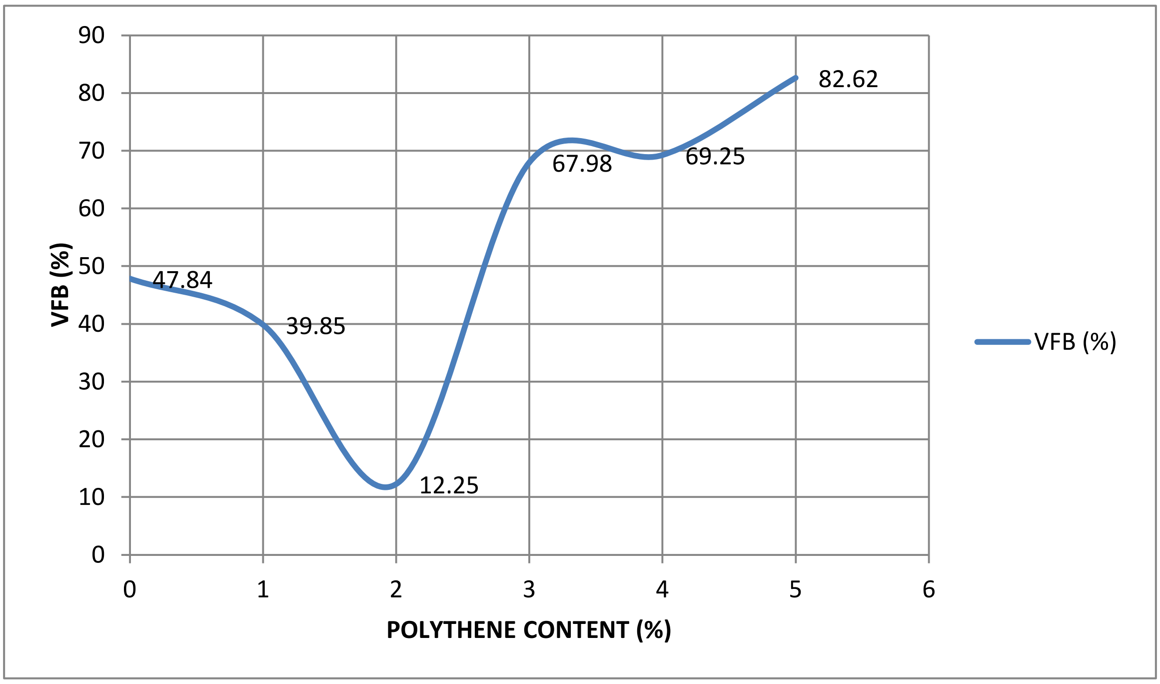

Fig.5: VFB vs. polythene content

ANALYSIS

Determining the ideal polythene content

The term "optimal polythene content" refers to the polythene content value at which the sample has the highest Marshall Stability Value and the lowest Marshall Flow Value.

The optimal polythene content is 4%, as shown in Figures 1 and 2. Additionally, we may infer from Figures 3, 4, and 5 that the voids in the mixture reduce when polythene is added.

CONCLUSIONS:

Bitumen's melting point is raised by plastics. Using these plastics in road construction is a cutting-edge technique that extends the life of the road while also strengthening it. In the near future, it is hoped that we will develop robust, long-lasting, and environmentally friendly roadways that will rid the planet of all plastic garbage. It has been found that the Marshall stability value rises up to 4% of the polyethylene content before falling. When polythene is added, we see that the Marshall flow value drops, increasing the material's resistance to deformation under high wheel loads. Additionally, the VMA, VA, and VFB parameter values fall within the necessary ranges.

FUTURE SCOPE:

The primary impact of plastic roadways is that solid trash proportionately rises with population growth. The ideal option is to use garbage as building material, which ensures proper disposal. The approach would be satisfactory in helping future generations manage solid waste because this way is cost-effective.

(i) Economic in terms of bitumen: The aggregates are covered by shredded plastic in the form of polymer, which takes up more space on the road and lowers the amount of bitumen required.

(ii) Effective non-biodegradable waste management: Plastic is a hazardous, non-biodegradable trash that primarily contributes to land contamination. It will be managed well if it is used for road development.

(iii) Simple procedure without new equipment: This method is straightforward and requires no sophisticated or new equipment.

(iv) Increased durability: Bitumen's strength and durability will be increased by the inclusion of plastic.

REFERENCES:

1. Shukla, R.S. and Jain, P.K., Improvement of waxy bitumen by the addition of synthetic rubbers, polymers and resins. Highway Res.Bull., 1984, 38, 17–28 (Indian Roads Congress, Delhi).

2. Button, J.W. and Little, D.N., Additives Have Potential to Improve Pavement Life,1998 (Roads and Bridges: USA).

3. Murphy M., O’Mahony M., Lycett C. and Jamieson I. (2001), “Recycled polymers for use as bitumen modifiers”, Journal of materials in civil engineering, Volume 13, pp. 306-314.

4. Mathew T. V. and Rao K. V. K. (2006), “Bituminous mix design”, Introduction to Transportation Engineering, NPTEL, pp. 24.1-24.5.

5. Partha Chakroborty & Animesh Das, Principles of Transportation Engineering, Published by Asoke K. Ghosh, Prentice-Hall of India Private Limited, 2005.

6. Sabina, Khan Tabrez A, Sangita, Sharma D.K., Sharma B.M, Performance Evaluation of Waste Plastic/ Polymers Modified Bituminous Concrete Mixes, Journal of Scientific and Industrial Research Vol.68,2009.

7. Gawande A., Zamare G., Renge V.C., Tayde S. And Bharsakale G. (2012), "An overview on waste plastic utilization in asphalting of roads", Journal of Engineering Research and Studies Vol. III/ Issue II.

8. Collins, J.H., Bouldin, M.G., Gelles, R. and Berker, A., Improved performance of paving asphalt by polymer modification. Proc. Assoc. Asphalt Paving Technol., 1991,60.

9. Khan I. and Gundaliya P. J. (2012), "Utilization of waste polyethylene materials in bituminous concrete mix for improved performance of flexible pavements", Journal of applied research, volume 1, issue 12, pp. 85-86.

10. IS: 1203 (1978), "Methods for testing tar and bituminous materials: determination of penetration", Bureau of Indian Standards, New Delhi.

11. MORTH specification (2001).

12. IS: 1205 (1978), "Methods for testing tar and bituminous materials: determination of softening point", Bureau of Indian Standards, New Delhi

13. Vasudevan, R., Utilization of waste plastics for flexible pavement, Indian Highways Indian Road Congress, Vol. 34, No.7, 2006.

14. Awwad M. T. and Shbeeb L (2007), "The use of polyethylene in hot asphalt mixtures", American Journal of Applied Sciences, volume 4, pp. 390-396.

15. Pareek A., Gupta T. and Sharma R. K. (2012), "Performance of polymer modified bitumen for flexible pavements", International journal of structural and civil engineering research, Volume 1, pp. 1-10