Evaluation of Properties of Porous Asphalt by Adding Granulated Waste Plastic

Vijay Pathania, Sandeep Singh

Abstract: ***Permeable asphalt also called as porous asphaltpervious asphalt is defined as a mixture which is designed to allow the water (storm water, runoff water) to percolate through the pores into the beneath layer .The permeable asphalt mixture contains more number of air voids as compare to the conventional bituminous mix, thus resulting in greatest stability and flow values as compared to the conventional bituminous mix. The main purpose of the study is to scrutinise the mechanical properties of porous asphalt mixtures with replacement of asphalt with polypropylene granulated plastic waste. The polypropylene waste plastic used in the study have size ranging from 2mm to 2.36mm and then it was melted at 240℃and mixed with asphalt .The asphalt was replaced with different percentage of polypropylene at 3%,4%,5%,6%,7%,8%,9%,10%.Different tests were conducted on bitumen such as softening point test, penetration test ,ductility test ,specific gravity test .The analysis of pervious asphalt mixture was carried out with different tests such as Marshall method (stability value and flow value), cantabro loss test ,binder drain down test, permeability test. This study shows that the value of stability and cantabro loss of modified permeable asphalt mixture with 9% partial replacement of bitumen is 2508.4 kg and 13.25% , higher than that of nominal permeable asphalt mixture which is 13.22%.***

Keywords**: *permeable asphalt, Polypropylene,Permeability***

I. INTRODUCTION

India is the country having higher rainfall intensity in many states.Heavy rainfall results in many defects to the pavement surface such as coagulation of water, pot holes, thus causing many problems to thehighway user making it uncomfortable and unsafe.In present world plastic is used everywhere in the form of plastic bottles,polyethylene bags etc. and to dispose of waste plastic isthe main catastrophe. While conducting different tests on the waste plastic it was seen that the waste plastic has good values and can be used in the asphalt mixture.Jiang conducted a study on asphalt pavement with addition of polypropylene and stated that polypropylene can reduce cracks in asphalt pavement. It is therefore possible to use polypropylene in the porous asphalt mixture. Following ASTM C1701, permeability of porous asphalt mixture should be 288 inch/hour to 750 inch/hour .Permeable asphalt mixture contains less percentage of fine aggregates as compare to the non-permeable asphalt mixture, resulting in less bonding of aggregates with each other. The void content ranges from 10% to 25%. The main goal of the study is to utilise the waste plastic material to develop a modified waste plastic asphalt mix with higher stability and desired flow value.

Revised Manuscript Received on June 05, 2019

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II. MATERIAL AND METHODS

A. Waste plastic

Waste plastic (polypropylene)Polypropylene (also called PP) is generally known as polypropylene. It is a form of thermoplastic polymer which is used in a catholic variety of applications. It is the second-most commonly produced plastic after polyethylene that is frequently used for packaging and labelling purposes .The properties of Polypropylene are somehow similar to polyethylene but it is more heat resistant and slightly harder than polyethylene. Polypropylene is a soft and flexible material. It is also considered as a "tough" material.

I. Physical properties of HDPE

S.no	Properties	Values
1	Melting point	125℃
2	Density	0.95-0.97
3	Tensile Strength	0.21 -0.40 N/mm^2
4	Specific gravity	0.90-1.0

B. Aggregates

For making permeable asphalt the maximum number of coarse aggregates ranging from 20mm to 2.36mm are used to make it permeable and very less amount of addition is computed of fine aggregates i.e., of 0.75micron.

II. Physical properties of aggregates

S.no	Aggregates test	Values
1	Crushing test	22.6%
2	Impact test	16.1
3	Abrasion test	22.2
4	Specific gravity	2.5

C. Asphalt

Asphalt is a sticky black material tends to high viscosity when melted beyond its ranges like 150℃and it also have its own specification like it plays a role of binding material for the pavements when it mixed with the aggregates.

III. Physical Properties of virginasphalt

S.no	Properties	Values
1.	Softening point	51.26℃
2.	Ductility	50.9
3.	Penetration	39mm

IV. PHYSICAL PROPERTIES OF MODIFIED ASPHALT

S.no	Properties	Values
1.	Softening point	64℃
2.	Ductility	59.1
3.	Penetration	42mm

III. METHODOLOGY

1. Collection of the material (aggregates, bitumen and polypropylene).
2. For preparing Marshal Sample firstly collect coarse aggregate,fine aggregate and filler and then place them in a pan . Place themin oven at a temperature of 160^0 C for pre heating so that the aggregate and bitumen can mix together in heated state.
3. By the side the bitumen was also heated up to its melting point before mixing (i.e. upto 150^0 C to 155^0 C).
4. The whole mix was stirred until it reached at a temperature of 150^0 C.
5. After mixing the whole mix is transferred to casting mould which is place in Marshall Compaction pedestal. The mix is then compacted with 50 no. of blows with the help of hammer and then sample is inverted and again compacted from the other face with same no. of blows.
6. Then the sample is extractedafter few hours from the mould and kept at room temperature for 24 hours.
7. Before testingfor marshall stability and flow the sample is kept in water bath having a temperature of 25^0 C for 30 minutes.
8. Finally find the percentage of void in coarse aggregate and air void in the compacted bitumen mix.

V. AGGREGATE GRADATION OF POROUS ASPHALT MIX

Sieve size,(mm)	Ranges as per NAPA	Gradation % Retained (gm)
19	100	0
13.2	85-100	162
9.5	55-75	273
4.75	10-25	495
2.36	5-10	199
.75	2-4	55

IV. TESTS AND RESULTS

There are several laboratory tests which are performed on the permeable pavement

A. Permeability test

The permeability of a permeable pavement should be 288 to 750 inches/hour (As per ASTMC 1701 code).

Prepare a sample of bituminous mix in a mould having diameter 4 inch.Prewet the bituminous mix with 500ml of water .Lines should be marked in the inner surface of the mould at 1cm and 1.5cm from the height of the bituminous mix. While pouring the water in the bituminous mix the rate of the water should be maintain between two marked lines.

Pour 1 litre of water into the bituminous mix maintain the head between 1cm to 1.5 and record the infiltration time in seconds.Further calculation are done by the formula.

$$I = \frac{K \times M}{D \times D \times T}$$

Where I = infiltration rate (in/hr)

K = constant

M = mass of water (2.20 lbs.)

D = diameter of mould (12")

And T = total time

VI. PERMEABILITY OF A TRIAL MIX

S.no	Mix	HDPE	I (in/hr)
1	V0	0	380
2	V6	6%	415

B. Cantabro Loss Test

This test is used to find out the breakdown of compacted specimen consuming the Los Angeles Abrasion apparatus.

Procedure:

1. Make a specimen mixture and then compact two specimens from that mixture.
2. Cool the compacted specimens to room temperature. Weight them and designate that specimen weight as 'A'.
3. After weighing place that specimen in the Los Angeles testing apparatus but do not place the steel balls in the Los Angeles testing apparatus.

4. Move the Los Angeles apparatus for up to 300 revolutions at a speed of 30–33 revolutions per minute.
5. After 300 revolutions take out the loose material of specimen that is broken off from the test specimen.
6. Do not take any part of the broken material in the weight that is to be taken then.
7. Weight that test specimen and then record that weight as 'B'.

CALCULATIONS:

Calculate the Cantabro Loss:

Cantabro Loss % = $\left(\frac{A-B}{A}\right)100$

Where:

A = Weight of test specimen initially

B = Weight of test specimen finally

VII. Results of cantabro loss test

HDPE %	Cantabro loss %
0%	13.93
3%	14.01
4%	14.98
5%	16.12
6%	16.89
7%	18.21
8%	18.99
9%	20.09
10%	20.57

C. Binder Drain DownTest

This test is used to evaluate the percentage of drain down measured value for a bituminous mixture to determine whether that is within the specified ranges. This test is particularly used for mixtures with coarse aggregate. Like permeable pavement and stone mastic asphalt.

Procedure:

1. Firstly take mass of loose mix and initial mass of pan.
2. Place the basket in the pan and transfer the loose mix to basket without disturbing itthen place them at the oven at 165℃temperature for 1 hour.
3. After 1 hour remove the basket and the pan from the oven and calculate final mass of the pan.

The Drain down of the mixture can be calculated by:

Drain down (%) = $\left[\frac{C-B}{A}\right]100$

Where
A = Initial mass of total sample (g)
B = Initial mass of pan (g)
And C = Final mass of pan (g)

VIII. DRAIN DOWN VALUES FOR VARIOUS PERCENTAGE OF POLYPROPYLENE

HDPE %	Drain down %
0%	6.345
3%	1.452
4%	1.102
5%	0.152
6%	0.101
7%	0.017
8%	0.012
9%	0.006
10%	0.004

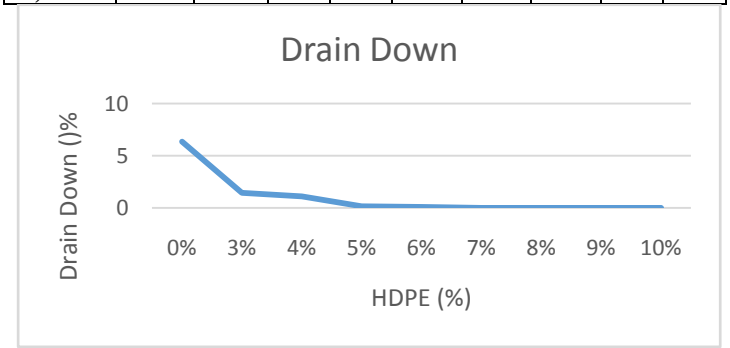
D. Marshall stability

IX. MARSHALL STABILITY TESTING FOR THE EVALUATION OF THE OPTIMUM BINDER CONTENT.

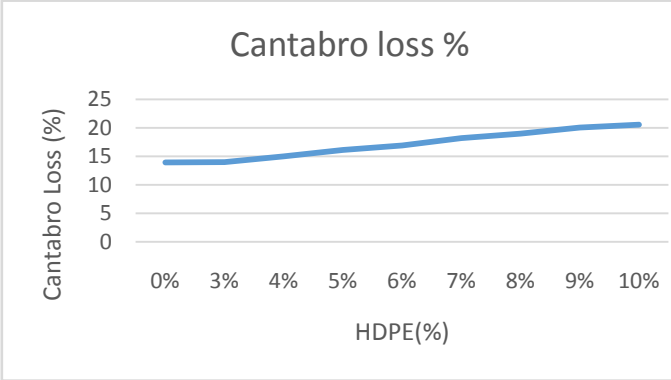
Marshall characteristics	Results			Ranges as per NAPA
Asphalt content (%)	5	5.5	6	Min-4.5
VMA(%)	24.9	23.7	23.2	Min-18
VA(%)	14.8	12.29	10.5	10-25
STABLITY	18.25	16	16.8	>500
DISPLACEMENT	2.71	1.95	7.24	2-6

X. PROPORTION OF ASPHALT AND HDPE

Material	OBC	P3	P4	P5	P6	P7	P8	P9	P10
Asphalt(gm)	68.4	66.348	65.66	64.98	64.296	63.612	62.928	62.24	61.56
HDPE(gm)	0	2.052	2.736	3.425	4.10	4.78	5.472	6.156	6.84



Fig(a): Drain down Test Result Graph



Fig(b): Cantabro Test Result Graph

XI. CONCLUSION

1. The permeability of permeable pavement gives the better results and makes it more permeable, when there is addition of the waste plasticby the replacement of the asphalt in a mix gives the better results.The use of the waste plastic (polypropylene) granulated forms will increase the permeability rate and makes the pavement more permeable.
2. As the addition of HDPE is increasing in the porous asphalt the value of cantabro loss goes on increasing.
3. The test results of marshal stability shows that the addition of HDPE (at 9%) withasphalt gives the best result and fulfil all the aspects.
4. As the value of HDPE is increasing the value of drain down test result is decreasing.

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