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OPTIMUM WASTE PLASTIC CONTENT IN BITUMINOUS CONCRETE PAVEMENT DESIGN

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ABSTRACT

In the plastic age , plastics have become a part parcel of our day today life. The fact that plastics have become a major source of pollution cannot be denied. Plastics as we know are non – biodegradable (most of them) and with approximately 100 million tons produced every year throughout the world, one can imagine their long term effect.

In this Project an attempt has been made to utilize these used plastics in asphalting of roads and thereby reduce pollution caused due to plastic to a considerable extent.

In the investigation, an attempt has been made to blend a particular percentage of plastic with bitumen and it has been found that this blend increases the strength of road which has been confirmed by the Marshall Stability Test results.

Further in this investigation it has been found that mixing of plastic with bitumen when used in asphalting of roads also improves certain qualities of road like penetration and softening point which have been confirmed by their respective tests.

Keywords:Waste Plastic, Bitumen, Gradation, Marshall stability test

I.INTRODUCTION

The Growth in various types of industries together with population growth has resulted inenormous increase in production of various types of waste materials, world over. The creation and disposal of non decaying waste material such as Blast Furnace Slag, Fly ash, Steel Slag, Scrap tiers, Plastic, etc have been posing difficult problems in developed as well as in developing countries. Considerable work has been done in various countries for the disposal of some of these waste products and utilization of some other products and there is a long list of published literature dealing with different aspects of these challenging problems.

It has been possible to improve the performance of bituminous mixes used in the surfacing course of road pavements, with the help of various types of additive to bitumen such as polymers , rubber latex crumb rubber –

treated with some chemicals etc., Some limited studies have been reported on the use of re-cycled plastic, mainly polyethylene, in the manufacture of polymer - modified asphalt cement or bitumen.

Re-cycled polyethylene from grocery bags may be useful in asphaltic (bituminous) pavements, resulting in reduced permanent deformation in the form of rutting and reduced low – temperature cracking of the pavements surfacing. It has been shown that re-cycled plastics composed predominantly of polypropylene andLow Density Polyethylene can be incorporated into conventional asphaltic (bituminous) road surfacing mixtures. Greater durability and fatigue life have been reported in these modified mixes as compared to conventional mixes.

II.OBJECTIVE OF THE STUDY

2.1 To determine the optimum bitumen content for different grades and proportion of bitumen and plastic in bituminous mix.

2.2 To study how different proportions of Plastic Waste in bitumen affect the strength and stability of bitumen grade 60/70.

2.3 To prepare test specimen of different proportion of bitumen and plasticfor bituminous mix and test their strength characteristics in Marshall Testing Machine.

III. MATERIALS AND METHODOLOGY

3.1 Bitumen

Bitumen is a petroleum product obtained by the distillation of crude petroleum. It is a hydrocarbon material of either natural or progenies origin, found in gaseous, liquid semisolid or solid form and is completely soluble in carbon disulphide and in carbon tetra chloride.

Bitumen is a complex organic material and occurs either naturally or may be obtained artificially duringthe distillation of petroleum. Bituminous materials are very commonly used in highway construction because of their binding and their water proofing technologies.

Table: 3.1 Properties of 60/70 grade bitumen

Description of Tests	**Test Results**	**Requirements as per IS:73-2002**	**Test Method**	**Remarks**
Bitumen Penetration (mm) at 25°C	67	60-70	IS:1203-1925	Good
Specific Gravity	1.02	0.99(minimum)	IS:1203-1925	Good
Softening Point (ºC)	46	45-55	IS:1203-1925	Acceptable

Ductility (cm) at 25°C	78	75(minimum)	IS:1203-1925	Good

3.2 Aggregates

Aggregate is acollective term for the mineral materials such as sand. Gravel and crushed stone that are use with a binding medium (such as water, bitumen, Portland cement, lime etc.,) to form compound materials.By volume, aggregate generally accounts for 92 to 96 percent of Bituminous concrete and about 70-80 percent of Portland cement concrete.

Table: 3.2 Properties of Aggregates

Description of Tests	**Test Results**	**Requirements as per MORTH Specifications**	**Test Method**	**Remarks**
Elongation Index (%)	19.95	Maximum 30%	IS:2386 Part IV-1963	Acceptable
Flakiness Index (%)	15.93	Maximum 30%	IS:2386 Part IV-1963	Acceptable
Aggregate Impact Value (%)	11.25	Maximum 24%	IS:2386 Part IV-1963	Acceptable
Los Angeles Abrasion Value (%)	10	Maximum 30%	IS:2386 Part IV-1963	Acceptable
Water Absorption (%)	0.2	Max 2%	IS:2386 Part IV-1963	Good
Aggregate Specific Gravity	2.65	2.6-2.9	IS:2386 Part IV-1963	Good

3.2.1Bulk Specific Gravity of the aggregates

The bulk specific gravity of the aggregates of sizes 13.2mm, 11.2mm, 6.7mm and fine aggregate is being found as per the IS code 2386 part IV-1963. The results are shown in the table below.

Table: 3.2.1 Specific gravity of aggregates

Aggregate Size	**Specific Gravity**
13.2mm	2.610
11.2mm	2.630
6.7mm	2.655
FA	2.650

3.3 Waste Plastic (Shredded form)

Plastic is the general common term for a wide range of synthetic ore semi synthetic organic solid materials suitable for the manufacture of industrial products. Plastics are typically polymers of high molecular weightand may containother substances to improve performance and / or reduce costs.

It refers to their malleability or plasticity during manufacture that allows them to be cast, pressed or extruded into an enormous variety of shapes - such as films, fibers, plates, tubes bottles boxesand much more.

3.3.1Physical Properties of Plastic

Different commercial plastic materials that are in use were collected and the following tests were carried out.

(i) Softening Point

(ii) Thickness of the Film

Most of the plastics get soften below 170`C except Poly Vinyl Chloride and Polyethylene Tetrepthalate. There is no evolutionof any gas during softening.The moltenplastics can be used as abinder using proper technique.

3.3.2Plastic as a Binder

Waste plastic is shredded into required size and mixed with hot stone (150-1700c) with uniform mixing. When heated to around 1500c to 1700c, they melt and in their molten state they spread over the stone as a thin liquid, which acts as a binder.

3.3.3 Process of Blending Plastic in Bituminous Mix

There are different processes of Blending plastic in bituminous mix we will mainly concentrate on two process of blending plastic i.e. wet process and dry process.

3.3.4 Wet Process

In wet process the Plastic waste (i.e Polyethylene Carry Bags) cut into pieces using shredding machine and of sieve size passing through 4.75 mm sieve and retaining at 2.36 mm sieve were mixed in Hot Bitumen.

In this process the Bitumen is heated to around 170-180`C and shredded plastic is added slowly. The mixture is stirred well using had stirrer or mechanical stirrer for about 20-30 minutes. Polymer bitumen mixtures of different composition is prepared and used for carrying out various test.

3.3.5 Dry Process

In dry process the aggregate is first heated to around 170`C and slowly the plastic (i.e. Polyethylene Cary Bags cut into pieces using shredding machine and of sieve size passing through 4.75 m sieve and retaining at 2.36 mm sieve is added. Then the aggregate is mixed well with the plastic waste, due to the high temperature the plastic waste melts and thin coating of plastic is formed over the aggregates. Then the Poly–coated aggregate so formedis mixedwith the hot bitumen at 160`Cand mixedwell.

The "Poly coated aggregate bitumen mixture" of different plastic content is prepared and used for carrying out various test.

IV.INDIVIDUAL GRADATION OF THE AGGREGATES AND MARSHALL METHOD OF MIX DESIGN

The Hot mix asphalt (HMA) selected in this work is Bituminous Concrete (BC) Grading II(as per MORTH specification). The MS-2 method of asphalt mix design is adopted and the steps are followed as stipulated in the procedure given below:

1. Individual Gradation of the aggregates.
2. Bulk Specific Gravity of the aggregates.
3. Combined Gradation of the aggregates or arriving Job mix formula.
4. Specimen preparation, testing and calculations.
5. Testing for Indirect tensile strength (ITS) at the optimum bitumen content (OBC).

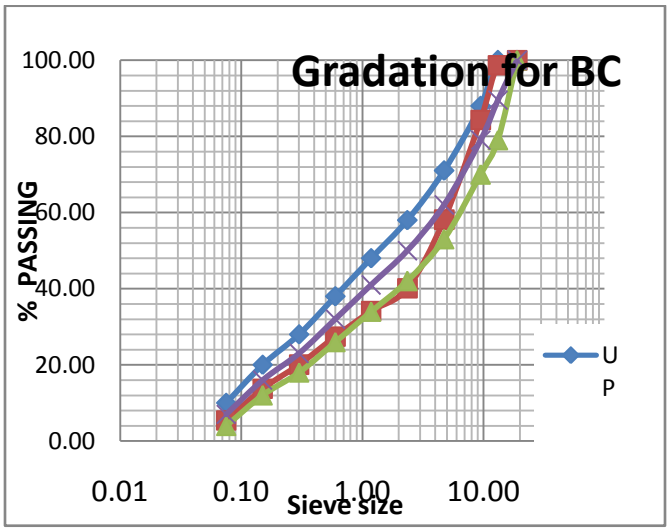
4.1 Individual Gradation of the aggregates

Aggregate gradation analysis and the combining of aggregates to obtain the desired gradation are the important steps in Hot mix asphalt design (MS-2). The individual gradation has been carried out for aggregate size 14mm-10mm, 10mm-4.75mm and 4.75mm down.

The designated sieves are arranged in order and the aggregates of different sizes have been sampled by proper methods and conducted two trials to find out the maximum percentage passing. The minimum weight of 2000 grams is been taken such that representing the proper aggregate fractions in finding the exact percentage of the materials retained on each sieve.

The results of the individual gradation arecombined and shown in the form of graph below

4.1.6:Graph showing combined gradation for Bituminous Concrete



4.1.6: Summary of Marshall Test results for 60/70 Grade Bitumen

A.C	G_{mb}	% V_a	%VMA	% VFB	Stability (KN)	Flow (in 0.25mm)
4	2.323	6.5	15.5	58.1	11.2	3.1
4.5	2.329	5.5	15.7	64.8	12.1	3.3
5	2.332	4.7	16.0	70.6	13.2	3.7
5.5	2.331	3.4	15.9	78.9	12.4	3.9
6	2.330	2.2	16.0	86.1	11.1	4.4

Where:

AC = Asphalt Content.

G_{mb}= Bulk Specific Gravity Of compacted Mixture.

G_{sb}= Bulk Specific Gravity Of Total Mixture.

V_a= Volume of Air Voids.

V_b= Volume of Bitumen

V_{ag}= Volume of aggregates.

VMA = Voids in Mineral Aggregates.

VFA = Voids Filled with Asphalt.

Graph: Stability v/s Binder content (60/70)

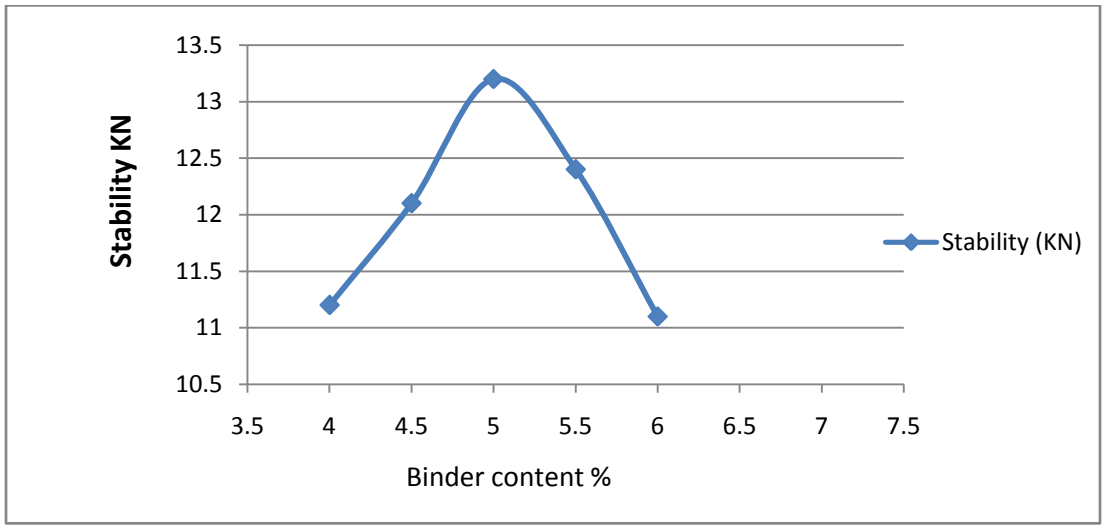
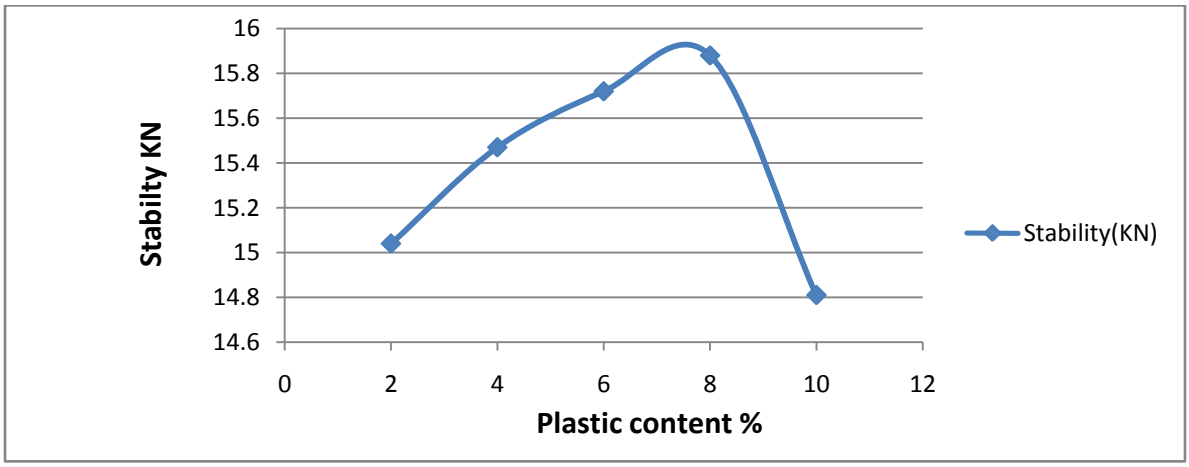


Table 4.1.7:Summary of Marshall Test results for Waste plastic with optimum binder content (Bitumen content)

W.P.C.	G_{mb}	% V_a	%VMA	% VFB	Stability(KN)	Flow (in 0.25mm)
2	2.28	9.3	18.14	48.9	15.04	3.9
4	2.31	8.1	18.15	55.3	15.47	4.2
6	2.34	5.9	16.95	67.1	15.72	4.8
8	2.36	5.0	17.52	71.3	15.88	5.3
10	2.37	3.0	16.82	82.1	14.81	5.4

Graph: Stability V/s Binder Content (waste plastic)



V. ANALYSIS OF THE TEST RESULTS AND DISSCUSSION

5.1General

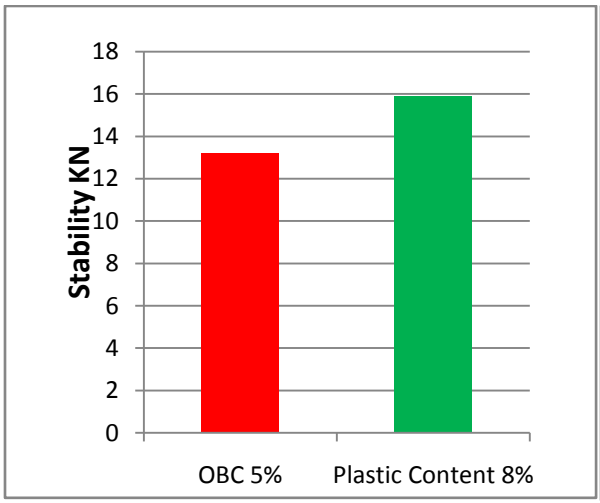
Investigations are carried out on the mechanical properties of bituminous mixes and the test results for bituminous concrete (BC) mix with conventionalbitumen (60/70) and waste plastic are analyzed for MarshallStability and the observations made on the results are presented and plotted in the following figures.

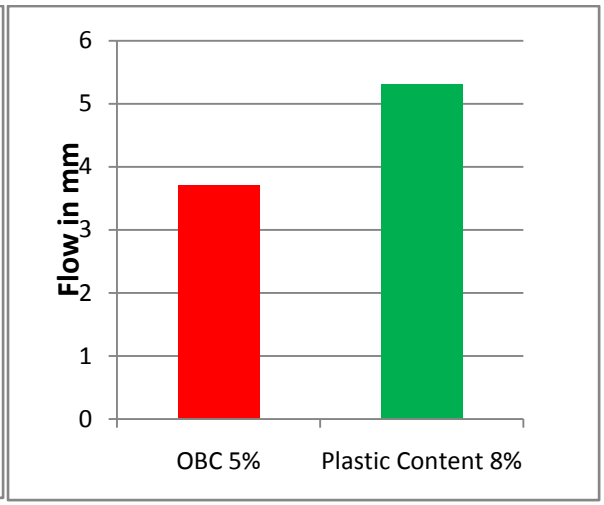
Table: 5.1.1 Comparison of Marshall test results

	Stability in KN	Flow in mm	Gmb	% Va	%VMA	%VFB
OBC 5%	13.2	3.7	2.332	4.7	16	70.6

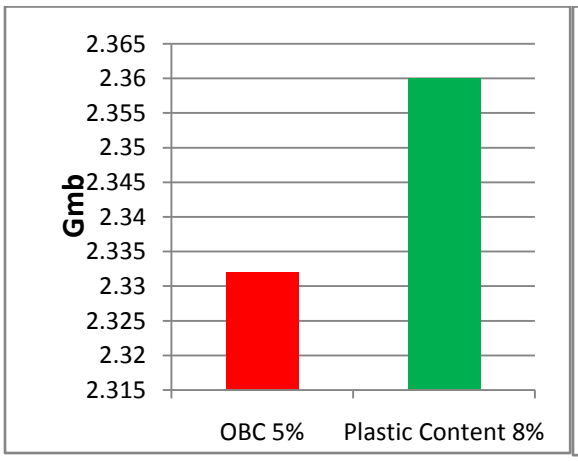
Plastic Content 8%	15.88	5.3	2.36	5	17.52	71.3

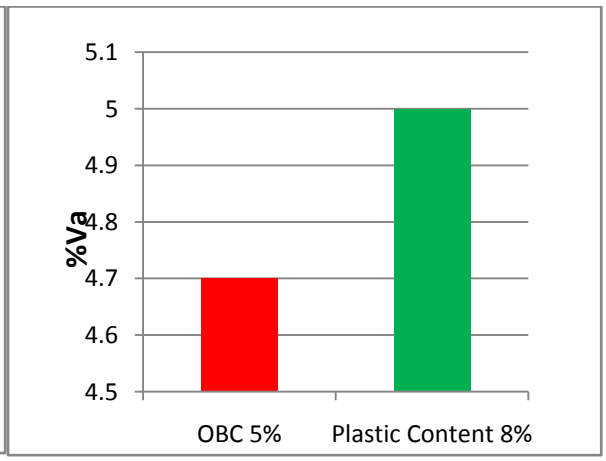
5.2 Analysis of Test Results



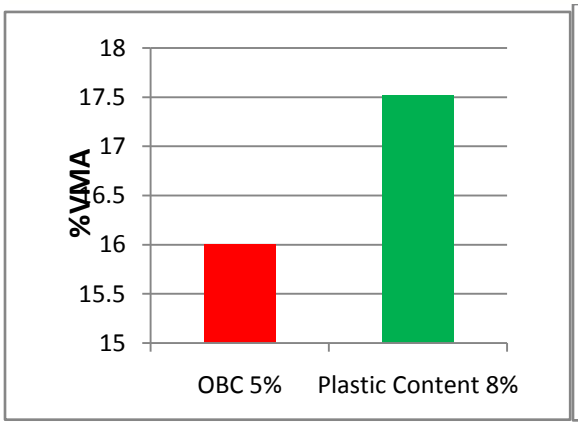


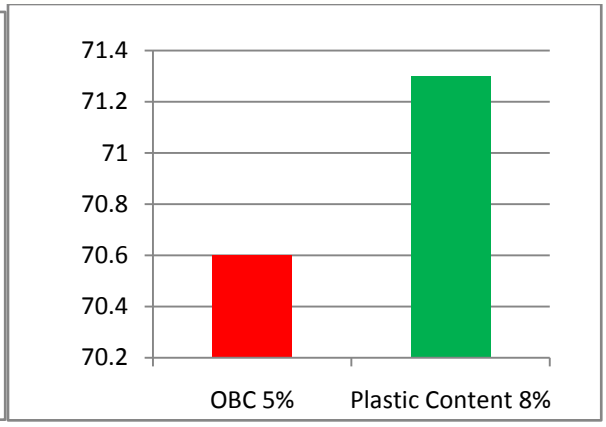
Graph: Stability Comparision Graph: Flow Comparision





Graph: Bulk Density ComparisionGraph: Air Voids Comparision





Graph: Voids in Mineral Aggregates ComparisionGraph: Viods Filled by Asphalt (Bitumen)

5.3Discussion

From Marshall mix design the optimum binder content found to be about 5% and waste plastic 8%. The stability is increased when waste plastic of 8% was added when compared to conventional bitumen (OBC is 5%).

VI.CONCLUSION

It can be concluded that, use of waste plastic could have a tremendous effect for improving theproperties of pavements compared to unmodified binders. Also, the stability of bituminous concrete mix can be increased drastically with an optimum waste plasticcontent to achieve the maximum pavement performance, and hence it improves the life of pavements.

6.1 Both the stability and stiffness of the mix get increased by using the waste plastic in the Mixes.

6.2 From Marshall Test it can be concluded that stability, flow value percentage of voids can be enhanced by using 8% of waste plastic in the mix.

VII. ACKNOWLEDGMENT

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REFERENCES

[1] Aslam andShahan-ur-Rahman(2009), "Use of Waste Plastic in Construction of Flexible Pavement", *New Building Materials & Construction World.*

[2] Khanna, S.K. and Justo, C.E.G., "Highway Engineering", 8thedn, Nem Chand & Bros, Roorkee (U.A), 2001

[3] Vasudevan,R. (2006), "Utilization of waste plastics for flexible pavement", *Indian High Ways(Indian Road Congress), vol. 34, no.7, pp.105-111.*

[4] IRC, "Guidelines for the Design of flexible pavements," IRC: 37-1970, Indian Roads Congress.

[5] IRC, "Tentative Specifications for Bituminous Surface dressing Using Pre-coated Aggregates," IRC: 48-1972, Indian Road Congress.

[6] A Support Manual for Municipal Solid Waste, Central Pollution Control Board, July 2003