A STUDY ON BITUMONOUS MIX PROPERTIES USING WASTE POLYETHYLENE

Ramawat Shashikanth
M.Tech, Highway Engineering
Gurunak College of Engineering & Tech
Ibrahimpatnam- 501506, Hyderabad

Mr. Raghuveer Narsing
Assistant Professor, Dept of Civil Engineering, Gurunak College of Engineering & Tech
Ibrahimpatnam-501506, Hyderabad

Prof. K. Vijaya Lakshmi
Prof. Dept. of Civil Engineering Gurunak College of Engineering & Tech
Ibrahimpatnam- 501506, Hyderabad

ABSTRACT

Bituminous mixes are most commonly used all over the world in flexible pavement construction. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which are mixed together, laid down in layers and then compacted. Under normal circumstances, conventional bituminous pavements if designed and executed properly perform quite satisfactorily but the performance of bituminous mixes is very poor under various situations. Today's asphaltic concrete pavements are expected to perform better as they are experiencing increased volume of traffic, increased loads and increased variations in daily or seasonal temperature over what has been experienced in the past. In addition, the performance of bituminous pavements is found to be very poor in moisture induced situations. Plastics are everywhere in today's lifestyle and are growing rapidly throughout particularly in a developing country like India. As these are non-biodegradable there is a major problem posed to the society with regard to the management of these solid wastes. Low density polyethylene (LDPE) has been found to be a good modifier of bitumen. Even, the reclaimed polyethylene originally made of LDPE has been observed to modify bitumen. In the present study, an attempt has been made to use reclaimed polyethylene which has been obtained from plastic packets used in packaging of a very popular brand of milk named AMUL, in dry form with the aggregates like a fibre in a bituminous mix. Detailed study on the effects of these locally waste polyethylene on engineering properties of Bituminous concrete (BC), Dense Bituminous macadam (DBM) and Stone mastic asphalt (SMA) mixes, has been made in this study.

***Keywords**: Optimum binder content (OBC), optimum polyethylene content (OPC), Bituminous concrete (BC), Dense Bituminous macadam (DBM), Stone mastic asphalt (SMA)*

I. INTRODUCTION

FLEXIBLE PAVEMENT

Flexible pavements are those, which on the whole have low flexural strength and are rather flexible in their structural action under loads. These types of pavement layers reflect the deformation of lower layers on-to the surface of the layer.

RIGID PAVEMENT

If the surface course of a pavement is of Plain Cement Concrete then it is called as rigid pavement since the total pavement structure can't bend or deflect due to traffic loads.

BITUMINOUS MIX DESIGN

The bituminous mix design aims to determine the proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical. There are two types of the mix design, i.e. dry mix design and wet mix design.

OBJECTIVE OF BITUMINOUS MIX DESIGN

1. Optimum bitumen content to ensure a durable pavement,
2. Sufficient strength to resist shear deformation under traffic at higher temperature,
3. Proper amount of air voids in the compacted bitumen to allow for additional compaction done by traffic,
4. Sufficient workability, and
5. Sufficient flexibility to avoid cracking due to repeated traffic load.

POLYMER MODIFICATION PRESENT SCENARIO

This paper is proposed bituminous binders are widely used in road paving and their visco-elastic properties are dependent on their chemical composition. Now-a-days, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a situation to think about some alternative ways for the improvement of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economical aspects.

OBJECTIVES OF PRESENT INVESTIGATION

A comparative study has been made in this investigation between SMA, BC, and DBM mixes with varying binder contents (3.5% - 7%) and polyethylene contents (0.5% - 2.5%).

- Study of Marshall Properties of mixes using both Stone dust as filler and, Slag as fine aggregate and fly ash as filler.
- The effect of polyethylene as admixture on the strength of bituminous mix with different filler and replacing some percentage of fine aggregate by slag.
- The performance of bituminous mix under water with and without polyethylene admixture with different filler and replacing some percentage of fine aggregate by slag.
- To study resistance to permanent deformation of mixes with and without polyethylene.
- Evaluation of SMA, BC, and DBM mixes using different test like Drain down test,
- Static Indirect tensile Strength test, Static Creep test etc.

RAW MATERIALS

CONSTITUENTS OF A MIX

Bituminous mix consists of a mixture of aggregates continuously graded from maximum size, typically less than 25 mm, through the fine filler that is smaller than 0.075mm. Sufficient bitumen is added to the mix so that the compacted mix is effectively impervious and will have acceptable dissipative and elastic properties. The bituminous mix design aims to determine the proportion of bitumen, filler, fine aggregates, and coarse aggregates to produce a mix which is workable, strong, durable and economical.

The basic materials used are as follows:

- Aggregates
- Fly Ash
- Slag
- Bituminous Binder
- Polyethylene

Aggregates

There are various types of mineral aggregates used to manufacture bituminous mixes can be obtained from different natural sources such as glacial deposits or mines and can be used with or without further processing. The aggregates can be further processed and finished to achieve good performance characteristics. Industrial by-products such as steel slag, blast furnace slag, fly ash etc. sometimes used by replacing natural aggregates to enhance the performance characteristics of the mix. Aggregate contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture. Hence, the quality and physical properties of the aggregates should be controlled to ensure a good pavement.

Aggregates are of 3 types;

- Coarse aggregates
- Fine aggregates
- Filler

Fly Ash

At present, as per the report of the Fly Ash Utilization Program me (FAUP), out of the huge quantity of fly ash produced, only about 35% finds its use in commercial applications such as mass concrete, asphalt paving filler, lightweight aggregate, stabilizer to road bases, raw material for concrete, additives to soil, construction of bricks etc. The remainder fly ash is a waste requiring large disposal area, causing a huge capital loss to power plants and simultaneously causing an ecological imbalance and related environmental problems (Dhir, 2005). In this investigation fly ash is used as one type of filler.

Granulated blast furnace slag

Granulated blast furnace slag (GBFS) is a by-product obtained in the manufacture of pig iron in the blast furnace and is formed by the combination of iron ore with limestone flux. If the molten slag is cooled and solidified by rapid water quenching to a glassy state, it results granulated blast furnace slag of sand size fragments, usually with some friable clinker- like material. The physical structure and gradation of granulated slag depend on the presence of chemicals such as lime, alumina, silica and magnesia, whose percentages may vary depending on the nature of iron ore, the composition of limestone flux and the kind of iron being produced. In present study granulated blast furnace slag is used as fine aggregates by replacing some gradation of natural aggregates.

Bituminous Binder

Bitumen acts as a binding agent to the aggregates, fines and stabilizers in bituminous mixtures. Bitumen must be treated as a visco-elastic material as it exhibits both viscous as well as elastic properties at the normal pavement temperature. At low temperature it behaves like an elastic material and at high temperatures its behavior is like a viscous fluid. Asphalt binder VG30 is used in this research work. Grade of bitumen used in the pavements should be selected on the basis of climatic conditions and their performance in past. It fills the voids, cause particle adhesion and offers impermeability.

Polyethylene

Stabilizing additives are used in the mixture to provide better binding property. Now-days Polypropylene, polyester, mineral and cellulose are commonly used as fibers. In this present Study polyethylene is used as stabilizing additive to improve performance characteristics of Pavement.

II. INPUT PARAMETERS

AGGREGATES

For preparation of bituminous mixes (SMA, DBM, BC) aggregates as per MORTH grading as given in Table respectively,

Gradation of aggregates for SMA

Sieve size (mm)	Percentage passing
19	100
13.2	94
9.5	62
4.75	28
2.36	24
1.18	21
0.6	18
0.3	16
0.075	10

Gradation of aggregates for BC

Sieve size (mm)	Percentage passing
19	100
13.2	79-100
9.5	70-88
4.75	53-71
2.36	42-58
1.18	34-48
0.6	26-38
0.3	18-28
0.15	12-20

Physical properties of binder

Penetration at 25℃ (mm)	IS : 1203-1978	67.7
Softening Point (℃)	IS : 1203-1978	48.5
Specific Gravity	IS : 1203-1978	1.03

Specific gravity of aggregates

Types of aggregate	Specific gravity
Coarse	2.75
Fine(stone)	2.36
Fine(slag)	2.45
Filler(stone dust)	2.7
Filler(Fly ash)	2.3

Physical properties of coarse aggregates

Property	Test Method	Test Result
Aggregate impact value (%)	IS : 2386 (P IV)	14.3
Aggregate crushing value (%)	IS : 2386 (P IV)	13.02
Los Angles Abrasion value (%)	IS : 2386 (P IV)	18
Flakiness index(%)	IS : 2386 (P I)	18.83
Elongation Index (%)	IS : 2386 (P I)	21.5
Water Absorption(%)	IS : 2386 (P III)	0.1

Gradation of aggregates for DBM

Sieve size (mm)	Percentage passing
37.5	100
26.5	90-100
19	71-95
13.2	56-80
9.5	-
4.75	38-54
2.36	28-42
1.18	-
0.6	-
0.3	7-21
0.15	-
0.075	2-8

III.RESULTS AND DISCUSSIONS

MARSHALL MIX DESIGN

Outline of Method The procedure for the Marshall method starts with the preparation of test specimens. Steps preliminary to specimen preparation are: All materials proposed for use meet the physical requirements of the project specifications.

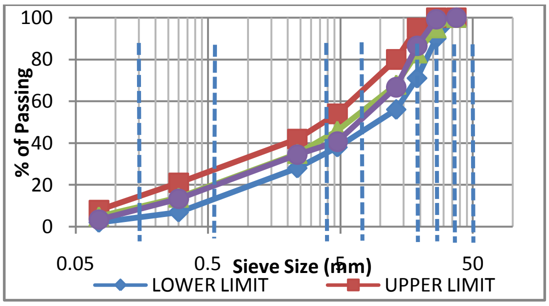
Aggregate blend combinations meet the graduation requirements of the project specifications.

For performing density and voids analyses, the bulk specific gravity of all aggregates used in the blend and the specific gravity of the asphalt cement are determined. These requirements are matters of routine testing, specifications, and laboratory technique that must be considered for any mix design method. Refer to chapter 3,.

The stability of the test specimen is the maximum load resistance in Newton's (lb.) that the standard test specimen will develop at 60^0 c when tested as outlined. The flow value is the total movement or strain, in units of 0.25mm occurring in the specimen between no load and the point of maximum load during the stability test.

BLENDING ANALYSIS									
Blending %	23 %	20 %	20 %	35%	2%	100 %	MORTH Limits		
	Average individual gradation (%of passing)								
Sieve Size mm	25 mm	20mm	10 mm	Dust	Filler	Combined	Lower Limit	Upper Limit	Mid Limit
37.5	100	100	100	100	100	100.0	100	100	100
26.5	96.41	100	100	100	100	99.2	90	100	95
19	50.09	90.18	100	100	100	86.6	71	95	83
13.2	9.4	38.06	99.7	100	100	66.7	56	80	68
4.75	0.85	0.15	18.56	99.3	100	40.7	38	54	46
2.36	0	0	7.93	88.38	100	34.5	28	42	35
0.3	0	0	0	32.48	100	13.4	7	21	14
0.075	0	0	0	4.1	98.91	3.4	2	8	5

COMBINED GRADATION GRAPH



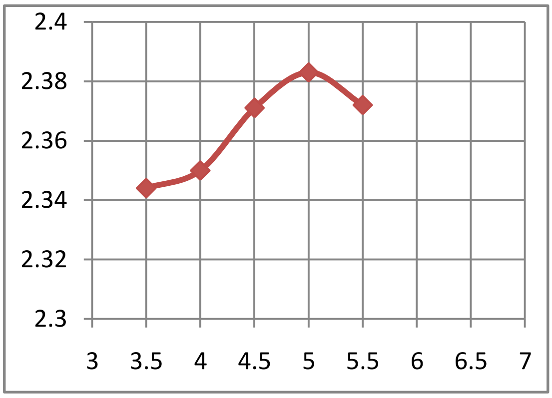
Preparation of mixture and packing the mould& Stability and flow test

Marshal Test Properties for VG-30 Mix

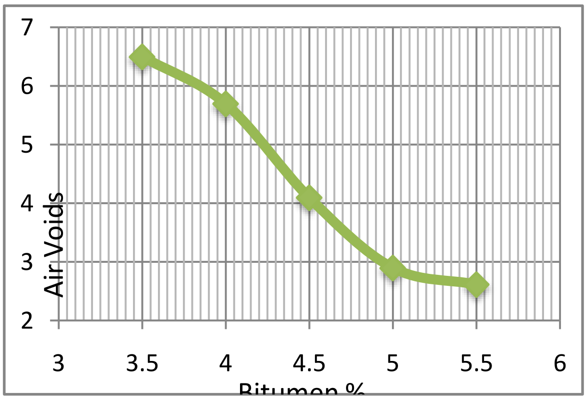
MARSHAL TEST PROPERTIES					
Bitumen %	**3.5**	**4**	**4.5**	**5**	**5.5**
Density	2.33	2.35	2.371	2.383	2.372
Max Specific Gravity	2.508	2.481	2.472	2.454	2.436
Va	6.5	5.7	4.1	2.9	2.62
VMA	12.41	12.14	11.83	11.84	12.71
VFB	45.42	57.17	65.34	75.59	79.39
Stability (Correction)	880	962	1075	1006	933
Flow in mm	3	3.3	3.7	4	4.2

OBC Determination for VG-30 grade Bituminous Mix Graphical Plot of Mix Properties Vs Binder Content for VG-30 Grade Bituminous Mix

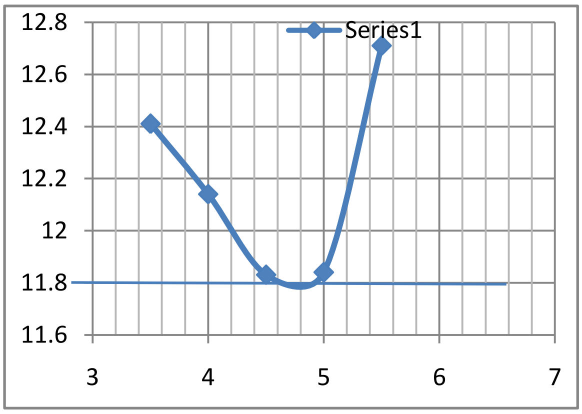
Binder Content (Vs) Density



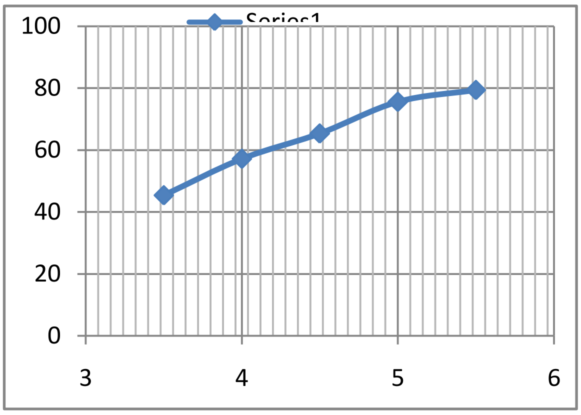
Binder Content (Vs) Air Voids



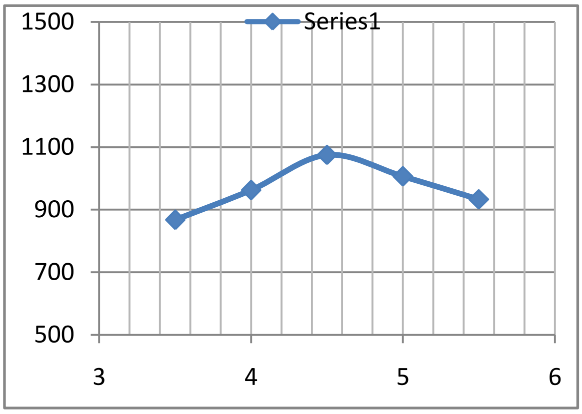
Binder Content (Vs) VMA



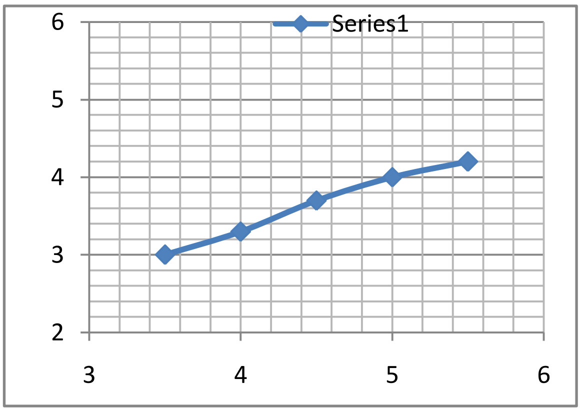
Binder Content (Vs) VFA



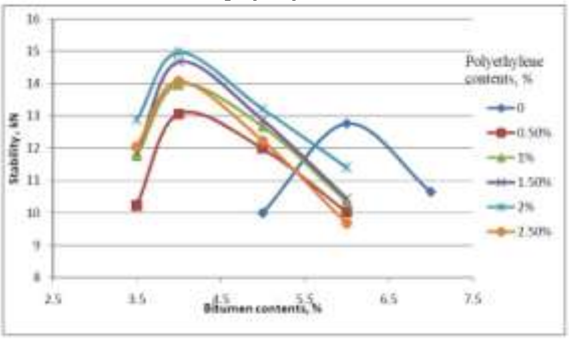
Binder Content (Vs) Stability



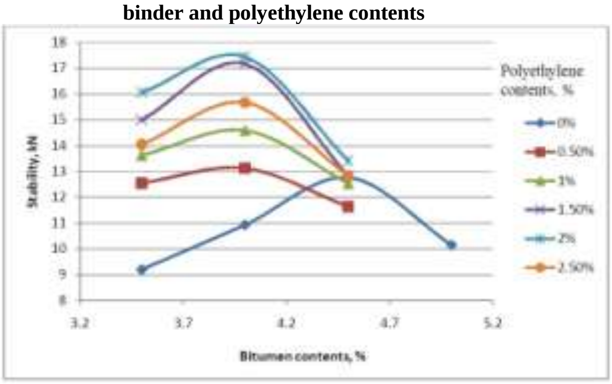
Binder Content (Vs) Flow



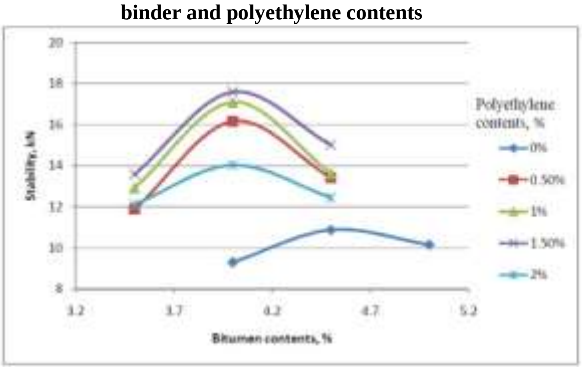
Variations of Marshall Stabilities of SMA with different binder and polyethylene contents



Variations of Marshall Stabilities of DBM with different binder and polyethylene contents



Variations of Marshall Stabilities of BC with different binder and polyethylene contents



OPTIMUM BINDER CONTENTS

Types of MIX	Optimum Polyethylene content(%)	Optimum binder content (%)
SMA without polyethylene	0%	6%
SMA with Polyethylene	2%	4%
DBM without Polyethylene	0%	4.5%
DBM with polyethylene	2%	4%

BC without Polyethylene	0%	4.5%
BC with polyethylene	1.5%	4%

Comparisons of stabilities at OBC

Types of mix with stone dust	Stability(kN)
SMA without polyethylene	12.765
SMA with polyethylene	14.965
DBM without polyethylene	12.76
DBM with polyethylene	17.444
BC without polyethylene	10.875
BC with polyethylene	17.587

Retained stability of SMA, BC, and DBM with and without polyethylene with fly ash and slag

Types of mix with fly ash and slag	After half an hour in water at 60°c	Avg. stability after 24 hours in water at 60°c	Avg. retained stability in %	Design requirements
SMA without polyethylene	13.94	10.87	74.98	Minimum 75% (as per MORTH Table 500-17)
SMA with polyethylene	16024	13.28	80.8	
BC with polyethylene	12.98	10.31	77.48	
DBM with polyethylene	18	14.72	81.78	
BC without polyethylene	14.23	11.51	75.9	
BC with polyethylene	18	14.48	84.45	

IV. CONCLUSIONS

1. Using Marshall Method of mix design the optimum bitumen content (OBC) and optimum polyethylene content (OPC) have been determined for different types of mixes. It has been observed that addition of 2% polyethylene for SMA and DBM mixes and 1.5%polyethylene for BC mixes results in optimum Mar shall Properties where stone dust is used as filler. But when small fraction of fine aggregates are replaced by granulated blast furnace slag and filler is replaced by fly ash, optimum Marshall Properties for all types of mixes result with only 1.5% polyethylene addition. The OBCs in case of modified SMA,BC and DBM mixes by using stone dust as filler are found 4% and OBCs in case of modified (i) SMA, and (ii) BC, and DBM by using fly ash and slag are found to be 5%and 4% respectively.

2. Using the same Marshall specimens prepared at their OPCs and OBCs by using both (i) stone dust as filler and (ii) replacing of stone dust by fly ash and fine aggregate by slag, for test under normal and wet conditions it is observed that the retained stability increases with addition of polyethylene in the mixes, and BC with polyethylene results in highest retained stability followed by DBM with

polyethylene and then SMA with polyethylene.

3. Addition of polyethylene reduces the drain down effect, though these values are not that significant. It may be noted that the drain down of SMA is slightly more than BC without polyethylene. However, for all mixes prepared at their OPC there is no drain down.

4. It is observed that by addition of polyethylene to the mixture, the resistance to moisture susceptibility of mix also increases. BC with polyethylene results in highest tensile strength ratio followed by DBM mixes with polyethylene and SMA mixes with polyethylene for both cases.

V.REFERENCES

1. AASHTO T 283, "Standard method of test for resistance of compacted asphalt Mixtures to moisture-induced damage", American association of state highway and transportation officials.
2. AASHTO T 305, "Drain-down characteristics in un-compacted asphalt mixtures", American association of state highway and transportation officials.
3. Ahmadinia E., Zargar M., Karim M. R., Abdelaziz M. and Ahmadinia E. (2012), "Performance evaluation of utilization of waste Polyethylene Terephthalate (PET) in stone mastic asphalt", Journal of Construction and Building Materials, Volume 36, pp. 984–989.
4. Airey G. D., Rahimzadeh B. and Collop A. C. (2004), "Linear rheological behavior of bituminous paving materials", Journal of materials in civil engineering, Volume 16, pp. 212-220.
5. Al-Hadidy A.I. and Yi-qiu T. (2009), "Effect of polyethylene on life of flexible pavements", Journal of Construction and Building Materials, volume 23, pp. 1456– 1464.
6. ASTM D 1559, "Test method for resistance of plastic flow of bituminous mixtures using Marshall Apparatus", American society for testing and materials.
7. ASTM D 6931 (2007), "Indirect Tensile (IDT) Strength for bituminous mixtures", American society for testing and materials.
8. ASTM D 792-08, "Standard test methods for density and specific gravity of plastic by displacement", American society for testing and materials.
9. ASTM D882–12, "Standard test method for tensile properties of thin plastic is sheeting", American society for testing and materials.
10. Attaelmanan M., Feng C. P. and AI A. (2011), "Laboratory evaluation of HMA with high density polyethylene as a modifier", Journal of Construction and Building Materials, Volume 25, pp. 2764–2770.