Use Of Waste Plastic Material In Bituminous Concrete Mixes

Mohammad Usman[1], Ushendra Kumar[2]
[1]M.Tech, Civil Engineering, Lucknow Institute of Technology, Lucknow, India
[2]Assistant Professor, Dept. of Civil Engineering, Lucknow Institute of Technology, Lucknow, India

***Abstract*— This research paper clarify about the work proposes application and better implementation of use of waste plastic material in bituminous concrete mixes.its main objective how we can use waste plastic material in bituminous concrete mixes without dumping the waste plastic in open ground also waste plastic can be as substitute of cement in several places but this thesis mainly focuses on waste plastic material behavior in bituminous concrete mixes. Bituminous Concrete (BC) is a composite material mostly employed in construction projects like road surfacing, airports, parking lots etc. It consists of asphalt or bitumen (used as a binder) and mineral aggregate which are mixed together & laid down in layers then compacted. Now a day, the gradual increment in high traffic intensity in terms of commercial vehicles, and the vital variation in daily seasonal and annual temperature put us in a demanding situation to think of some alternatives for the improvisation of the pavement features and quality by applying some suitable modifications that shall satisfy both the strength as well as economical aspects. Also considering the environmental approach, because of excessive use of polythenes in daily life, the all kind of pollution to the environment are increases termendously. Since the polythenes are not biodegradable, the need of the current time is to use the waste polythene in some beneficial purposes. This paper presents a research conducted to review the behavior of BC mix modified with waste plastic material. Various percentages of polythene or synthetic resin are used for preparation of mixes with a particular aggregate grading as per mention in IRC Code. The role of polythene in the mix is studied for various engineering properties by preparing Marshall samples of bituminous concrete mixtures with and without polymer. Marshall properties such as stability, flow value, unit weight, air voids are used to determine optimum polythene content for the given grade of bitumen (80/100).**

Keywords: Bituminous Concrete (BC), Marshall stability, Flow value, Optimum Polythene Content,Waste Polythenes

1. INTRODUCTION

Bituminous binders are broadly used by paving industries. A pavement has different layers. The main constituents of bituminous concrete (BC) are aggregates and bitumen. Generally, all the hard and brittle surfaced pavement types are categorized into 2 groups, i.e.

Flexible and Rigid pavement

- Flexible Pavement :

Versatile pavement are surface course of a pavement is bitumen then it is called "flexible" since the total pavement structure can bend or deflect due to traffic loads.

- Rigid Pavement :

If the surface course of a pavement is PCC then it is called "rigid" since the total pavement structure can't bend or deflect because of traffic loads there is load can be transferred by slab action. Such pavements are abundant much stiffer than the flexible pavements due to the high modulus of elasticity of the Plain Cement Concrete material. Importantly, we can use reinforcing steel within the rigid pavements, to decrease or eliminate the joints.

In this research paper section I contains the introduction, section II contains the objective details, section III contains the details about Waste plastic is a concern, section IV describe the related work, section V provide details of basic material, section VI describes the experimental work, section VII provide the result details, section VIII provide conclusion of this research paper.

2. Objectives of mix design

The bituminous mix design focuses to estimate the proportions of bitumen, filler material, fine aggregates, coarse aggregates & polythene to produce a mix which should have workability in the appropriate range so that there is no segregation under load- Enough strength to survive heavy wheel loads & tyre pressures.

- Sufficient durability
- Must be economical

3. Waste plastic is a concern

Plastics are durable & non biodegradable cannot be decomposed the chemical bonds make plastic very durable & resistant to normal natural processes of degradation. Since 1950s, around 1 billion tons of plastic have been discarded, and that they may might persist for hundreds or even bunch of years. The plastic gets mixed with water, does not disintegrate, and takes the form of small pallets which causes the death of fishes and many other aquatic animals life as well as waster ecosystem. Today the availability of the plastic wastes is in huge amount, as the plastic materials have become the part of our daily life. Either they get mixed with the Municipal Solid Waste or thrown over a land area. If they are not recycled, their present disposal may be by land filling or it may be by incineration process. Both the processes have significant impacts on the environment. If they are incinerated, they polluted the air with very unwanted gases such as carbondioxide,nitrogendioxide etc, and if they are dumped into some place, they cause soil & water pollution. Under these circumstances, an alternate use for these plastic wastes is required.

4. RELATED WORK

4.1 Evolution of mix design concepts

- During 1900's, this technique, of using bitumen in pavements, was firstly used on rural roads in order to stop rapid removal of the fine particles such as dust, from Water Bound Macadam, which was caused because of fast growth of automobiles [Roberts et al. 2002]. At initial stages, heavy oils were used as dust palliative. An eye estimation process which is called pat test, was used to estimate the required quantities of the heavy oil, in the mix.
- The 1st formal technique of mix design was Habbard field method, which was actually developed on sand-bitumen mixture. Mixtures with larger sized aggregates particles could not be handled during this technique. This was one limitation of this procedure.
- Francis Hveem, 1942; who was a project engineer of California, Department of Highways enginering, has developed the Hveem stabilometer in 1927. He did not have any previous experience on judgement that, the required mix from its colour, hence he decided to measure various mixture parameters to find the optimum quantity of bitumen [Vallegra and Lovering 1985]. He had applied the surface area calculation concept, (which was already in use, at that time for the cement concrete mix design), to estimate the quantity of bitumen actually required.
- Bruce Marshall developed the Marshall testing machine just before the World War
- It was adopted in the US Army Corpes of Engineers in 1930's and subsequently modified in 1940's and 50's.

4.2 Polymer modification

- Bahia and Anderson, 1984; studied about the visco-elastic nature of binders and found that, the complex modulus & phase angles of the binders, need to be measured, at temperatures and loading rates with which different resemble climatic and loading conditions as well as past conditions.
- Shukla and Jain (1984) described that the effect of wax in bitumen can be decreased by adding EVA (Ethyl Vinyl Acetate), aromatic resin and SBS in the waxy bitumen. The addition of 4% EVA or 6% SBS or 8% resin in waxy bitumen effectively degraded the Susceptibility to high temperatures, bleeding at high temperature and brittleness at low temperature of the mixes.
- The findings of the studies conducted by the Shell Research and Technology Centre in Amsterdam indicated that the rutting rate is enormously reduced by the result of SBS modification of the binder. Button and Little (1998) on the basis of stress controlled fatigue testing at 20 and 0^0C, reported that SBS polymer exhibited superior fatigue properties as compared to straight AC-5 bitumen.
- Shuler et al. (1987) found that the tensile strength of SBS modified binder rised considerably as compared to unmodified asphalt mix at -21, 25$^{\text{and }41}$^{0}C.

- Collins et al. (1991) and Baker (1998) reported that SBS modified asphalt mixes have longer lives than unmodified asphalt mixes. The addition of SBS polymer to unmodified bitumen also increases its resistance to low temperature cracking.
- Denning and Carswell (1981) according that asphalt concrete using polyethylene modified binders were more resistant to permanent defor mation at elevated temperature.
- Palit et al. (2002) found improvement in stripping characteristics of the crumb rubber modified mix as compared to unmodified asphalt mix.
- Sibal et al. (2000) evaluated flexural fatigue lifetime of asphalt concrete modified by 3% crumb rubber as a part of aggregates.
- Goodrich (1998) according that fatigue life and creep properties of the polymer modified mixes increased considerably as compared to unmodified asphalt mixes.
- The Indian Roads Congress Specifications Special Publication: fifty three (2002) indicate that the period of next renewal may be extended by 50% in case of surfacing with modified bitumen as comparing with unmodified bitumen.

4.3 Recent applications

- A 25 km plastic changed bituminous concrete road was set in Bangalore. This plastic road showed superior smoothness, uniform behaviour and fewer rutting as compared to a plastics-free road which was laid at same time, which began developing terrible “crocodile cracks” very soon after. The process has also been approved, in 2003 by the CRRI (Central Road Research Institute Delhi).
- Justo et al (2002), at the Centre for Transportation Engineering, at Bangalore University used processed plastic luggage bags as associate additive in asphalt concrete mixes. The properties of this modified bitumen were compared to that of ordinary bitumen. It was noted that penetration and ductility values, of modified bitumen was decreasing with the rise in proportion of the plastic additive, up to 12 % by weight.
- Mohammad T. Awwad et al (2007), polyethylene as synthetic resin collectively variety of polymers employed to research the potential prospects to boost asphalt mixture properties. The objectives also include determining the best type of polyethylene to be used and its proportion. Two types of polyethylene were added to coat the aggregate
- High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE). The results indicated that grinded HDPE polyethylene modifier provides better engineering properties. The recommended proportion of the modifier is 12% by the weight of bitumen content. It is found to extend the stability and soundness, reduce the density and slightly increase the air voids and the voids of mineral aggregate.
- Shankar et al (2009), crumb rubber modified bitumen (CRMB 55) was blended at specified temperatures. Marshall’s mix design was applied by ever changing the modified bitumen content at constant optimum rubber content and subsequently tests have been performed to determine the different mix design characteristics and for conventional bitumen (60/70) additionally. This has resulted in much improved characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67%).

5. Basic materials

5.1 Aggregate

Aggregate constitutes the granular part in bituminous concrete mixtures which contributes up to 90-95 % of the mixture weight and contributes to most of the load bearing & strength characteristics of the mixture. Hence, standard of the quality and physical properties of the aggregates should be controlled to ensure a good pavement. The properties that aggregates should have to be utilized in pavement are shown below-

- Aggregates should have minimal plasticity for better output. The presence of clay fines in bituminous combines can result in problems like swelling and adhesion of bitumen to the rock which may cause stripping problems. Clay lumps and friable particles should be limited to utmost 1%.
- Durability or resistance to weathering should be measured by sulphate soundness testing.
- The ratio of dust to asphalt cement, by mass should be a maximum of 1.2 & a minimum of 0.6.It is suggested for better result AASHTO T-209 to be used for determinant

the maximum specific gravity of bituminous concrete mixes.

5.2 Bitumen

- Asphalt binder 60/70 and 80/100 are used in this research. The bitumen used should have the following required properties.
- Grade of bitumen used in the pavements should be selected on the basis of climatic conditions and their performance in recent days.
- It is usually recommended that the bitumen should be accepted on certification by the supplier (along with the testing results) and also the State project, verification samples. The procedures for acceptance should provide information, on the physic al properties of the bitumen in timely manner.
- The physical properties of bitumen used which are very important for pavements are shown below. Every State should obtain this information (by central laboratory or supplier tests) and should have specification necessities for each property except specific gravity of bitumin.

5.3 Mineral Filler

Mineral filler consists of, very fine, inert mineral matter that is added to the hot mix asphalt, to increase the density and enhance strength of the mixture. These fillers should pass through 75µm(micron) IS Sieve.
The fillers may be cement or fly ash.

6 EXPERIMENTAL WORK

6.1 General

It involves mainly 2 processes. i.e.

a) Preparation of samples
b) Void analysis
c) Testing

Prior to these experiments, the specific gravity of polythene used was calculated as per the guidelines provided in ASTM D792-08.

Determination of specific gravity of polythene
The procedure adopted is given below

- The weight of the polythene in air was measured by a balance. Let it be denoted by "a".
- An immersion vessel full of water was kept below the balance.
- A piece of iron wire was attached to the balance such that it is suspended about 25 mm above the vessel support.
- The polythene was then tied with a sink by the iron wire and allowed to submerge in the vessel and the weight was measured. Let it be denoted as "b".
- Then polythene was removed and the weight of the wire and the sink was measured by submerging them inside water. Let it be denoted as "w".

The specific gravity is given by

$$s = a / (a + w - b)$$

6.2 Mixing Procedure

The mixing of ingredients was done as per the following procedure (STP 204-8).

- Required quantities of coarse aggregate, fine aggregate & mineral fillers were taken in an iron pan.
- This was kept in an oven at temperature 160^0C for 2 hours. This is because the aggregate and bitumen are to be mixed in heated state so preheating is required.
- The bitumen was also heated up to its melting point prior to the mixing.
- The required amount of shredded polythene was weighed and kept in a separate container.
- The aggregates in the pan were heated on a controlled gas stove for a few minutes maintaining the above temperature.
- The polythene was added to the aggregate and was mixed for 2 minutes.
- Now bitumen (60 gm), i.e. 5% was added to this mix and the whole mix was stirred uniformly and homogenously. This was continued for 15-20 minutes till they were properly mixed which was evident from the uniform colour throughout the mix.
- Then the mix was transferred to a casting mould.
- This mix was then compacted by the Marshall Hammer. The specification of this hammer, the height of release etc.
- 75 no. Of blows were given per each side of the sample so subtotal of 150 no. of blows was given per sample.
- Then these samples with moulds were kept separately and marked

Figure – 1: MARSHALL SAMPLES

Figure 2: CLOSER VIEW OF A MARSHALL SAMPLE

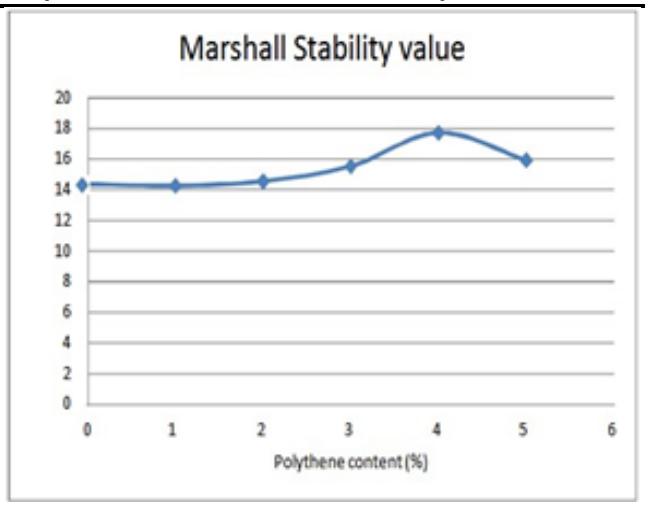

Figure 3 Marshall Stability

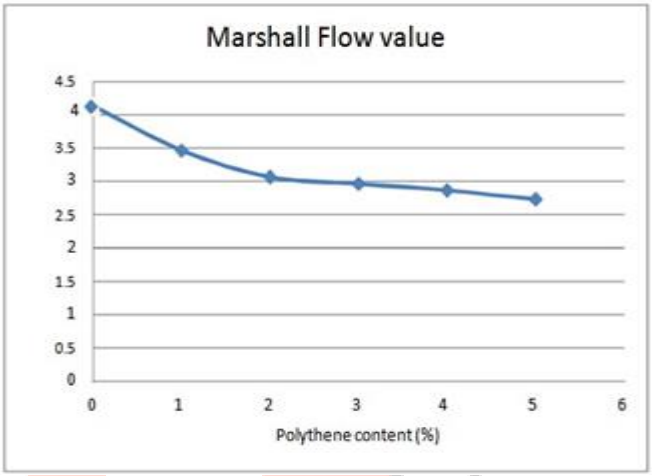

Figure 4: Marshall Flow Value

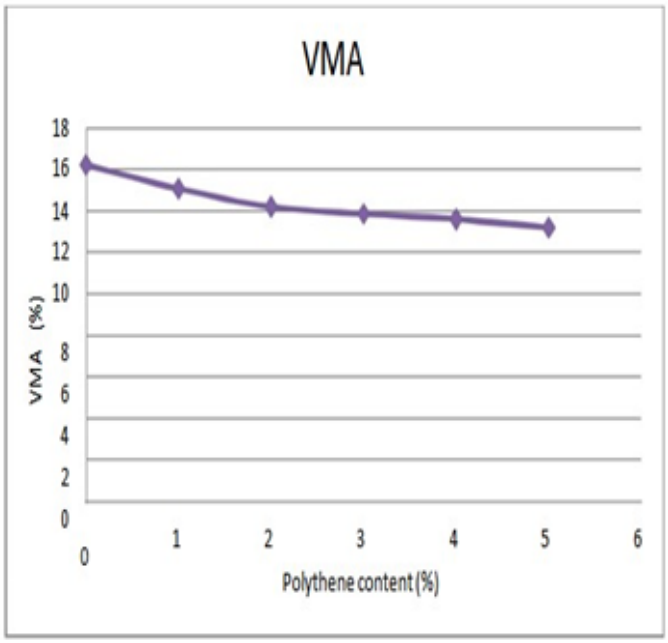

Figure 5 VMA vs Polythene

7 RESULTS

7.1 Plotting Curves

Five curves were plotted. i.e.

i. Marshall Stability Value vs. Polythene Content
ii. Marshall Flow Value vs. Polythene Content
iii. VMA vs. Polythene Content iv. VA vs. Polythene Content
v. VFB vs. Polythene Content
vi. Bulk unit weight vs. Polythene Content

For each % of polythene, 3 samples have been tested. So the average value of the 3 was taken.

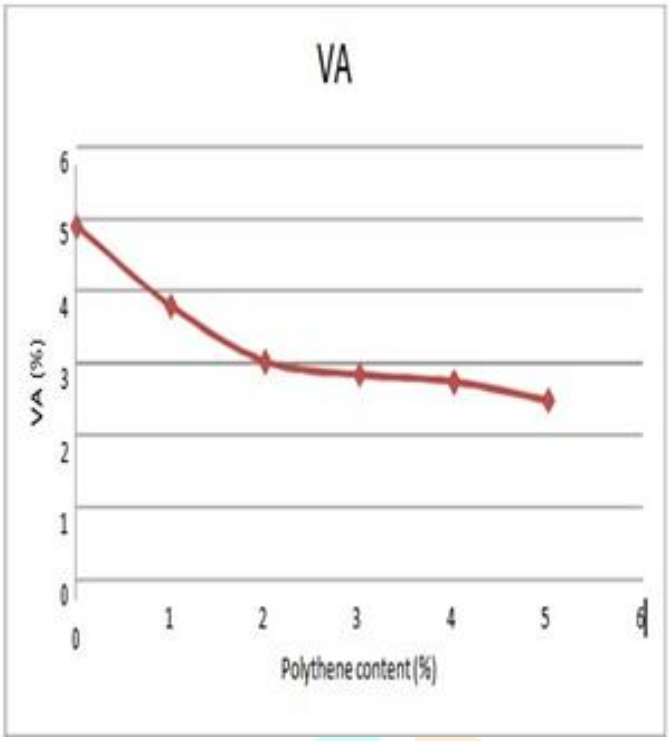

Figure 6: VA vs Polythene

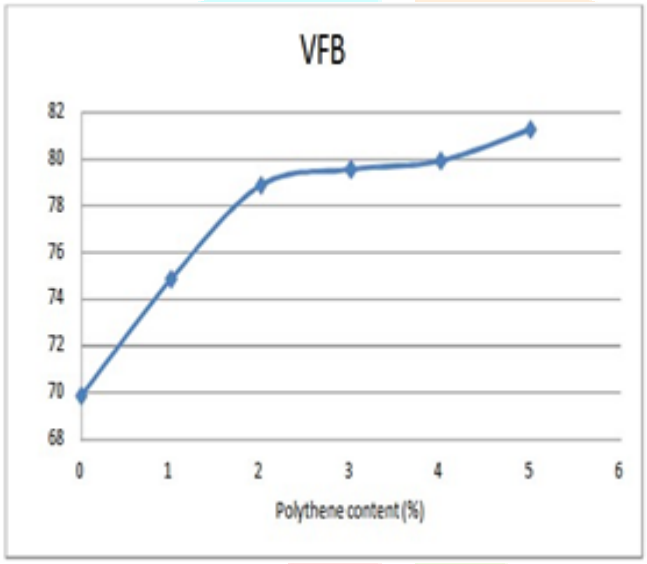

Figure 7: VFB vs Polythene

8 CONCLUSION

The study of the behaviour of polythene modified BC it was found that the modified mix possesses improved Marshall Characteristics as mentioned below. It is observed that Marshall stability value increases with polyethylene content upto 4% and thereafter decreases. we observe that the marshall flow value decreases upon addition of polythene i.e the resistance to deformations under heavy wheel loads increases. Also the values of the parameters like VMA, VA, VFB are within the required specifications. Considering these factors we can assure that we can obtain a more stable and durable mix for the pavements by polymer modifications. This small investigation not only utilizes beneficially, the waste non-degradable plastics but also provides us an improved pavement with better strength and longer life period. Polymer modified pavements would be a boon for India's hot and extremely humid climate, where temperatures frequently rises past 50°C and torrential rains create havoc, leaving most of the roads with heavy distresses. This adversely affects the life of the pavements. The polymer modified bitumen show improved properties for pavement constructions. This also can reduce the amount of plastics waste which otherwise are considered to be a threat to the hygiene of the environment. In this modification process plastics-waste is coated over aggregate. This increases the surface area of contact at the interface and ensures better bonding between aggregate and bitumen. The polymer coating also reduces the void spaces present in the mix. This prevents the moisture absorption and oxidation of bitumen by entrapped air. The road can withstand heavy traffic and show better service life. This study will have a positive impact on the environment as it will reduce the volume of plastic waste to be disposed off by incineration and land filling. It will not only add value to plastic waste but will develop a technology, which is eco-friendly. However, it is recommended that more research regarding the topic should be done and more trial sections should be laid and their performance should be studied.

REFERENCE

1) Annual Book of ASTM Standards, 1999. ASTM D-6373, Standard Specification for

Performance Grading of Asphalt Binder, pp: 1102-1136.

2) Aslam Shahan-ur-Rahman "Use of Waste Plastic in Construction of Flexible Pavement",

New Building Materials & Construction World, in 2009.

3) Bahia, H.U. and Anderson, D.A., Strategic highway research program binder rheological parameters: Background and comparison with conventional properties. Transport. Res. Rec. 1488, 1995, 32, 39.Vasudevan R., Nigam S.K., Velkennedy R., Ramalinga Chandra

Sekar A., Sundarakannan B. Utilization of Waste Polymers for Flexible Pavement and

Easy Disposal of Waste Polymers, International Conference on Sustainable Solid Waste Management, 5 - 7, Chennai, India pp-105-111, 2007. Baker, R.E., Polymer modified
bitumen. Indian Highways, 1998, 1, 85–94.

4) Button, J.W. and Little, D.N., Additives Have Potential to Improving Pavement Life, 1998

(Roads and Bridges: USA).

5) Collins, J.H.,Bouldin, M.G., Gelles, R.and Berker, A., Improved performance of paving

asphalt by polymer modification. Proc. Assoc. Asphalt Paving Tec hnol., 1991, 60.

6) Das, A., (1998). Analytical design of bituminous pavements based on field performance,

not published PhD thesis, Civil Engg. Dept., IIT, Kharagpur.

7) Denning, J.H. and Carswell, J., Improvement in rolled asphalt surfacing by the adding of

organic polymers, Report LR 989, TRRL, Crowthrone 1981.

8) Justo C.E.G. and Veeraragavan A "Utilization of Waste Plastic Bags in Bituminous Mix for Improved Performances of Roads", Centre for Transportation Engineering, Bangalore University, Bangalore, India, 2002.

9) Palit, S.K., Reddy, M.A., Reddy, K.S. and Pandey, B.B., Performance evaluation of crumb rubber modified bituminous mixes. Proceedings with National Seminar on Road Transportation in India: Emerging Trends and Techniques, 2002 September 12–13 (IIT Kharagpur: India).

10) Pandey,B.B., "Bituminous Mix Design", A Two Day Workshop on Design of Flexible Pavement with Emphasises on the New IRC:37-2001 Guidelines, 9-10 February, IIT
Kanpur, 2002.

11) Partha Chakroborty & Animesh Das, Principles of Transportation Engineering, Published

by Ashok K. Ghosh, Prentice-Hall of India Private Limited, 2005.

12) Sabina, Khan Tabrez A, Sangita, Sharma D.K., Sharma B.M, Performance Evaluation. of

Waste Plastic/ Polymers or synthetic resins Modified Bituminous Concrete Mixes,

Journal of Scientific and Industrial Research Vol.68,2009.

13) Shukla, R.S. and Jain, P.K., Improvement of waxy bitumen by the adding of synthetic

rubbers, polymers and synthetic resins. Highway Res.Bull., 1984, 38, 17–28 (IRC, Delhi).

14) Shuler, T.S., Collins, J.H. and Kirkpatrick, J.P., Polymer modification in asphalt properties related to asphalt concrete performance in past. In Asphalt Rheological Relationship to Mixture, ASTM, STP 941, edited by O.E. Briscoe, 1987 (ASTM:
Philadelphia).

15) T. Awwad Mohammad and Sheeb Lina, the Use of Polyethylene in Hot Asphalt

Mixtures, American Journal of Applied Sciences 4 (6) pp-390-396, 2007.

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