www.ijraset.com Volume 4 Issue IV, April 2016
IC Value: 13.98 ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

In Bituminous Concrete Mixes Utilization of Waste Plastic Materials

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Abstract* - The constant growth in road traffic couple with an inadequate degree of maintenance due to lack of funds has caused a continuous and accelerated deterioration of the road network. To improve this process, numerouskinds of methods are stated to be in effect, for instance, obtaining funds for maintenance, enhanced roadway design, utilization of goodquality of materials and the utilization of more effective construction techniques. Improving the quality of materials utilized in road construction had been presented to increase road service performance. Practical understanding over the last four decades have presented that the variation of the bituminous binder with polymer additives deals several benefits in bituminous concrete and has been verified in a number of countries everywhere in the World. The utilization of waste plastic materials has received a great improvement due to its plentiful supply and high resistance to insects, fungi, animals, as well as molds, mildew, rot and many chemicals. However the disposal of the waste plastic materials in huge amounts has been a problem all over the country. So this investigation was designed to examine the influence of waste plastic in the bituminous concrete properties. Waste plastic was added in grinded state as binder modifier. It was added to the blend by melting it in the bitumen used in making the bituminous concrete blend. Marshall Mix design method was utilized, first to find out the optimum bitumen binder content and then tested the modified blend properties. In total, 11 samples were prepared (6 samples were utilized to find out the optimum bitumen content and the remaining samples were utilized to study the effect of modifying the asphalt mixtures). The optimum bitumen content was 4.5%. Five proportions of waste plasticby weight of the optimum bitumen content were selected to be tested (1.0, 2.0, 3.0, 4.0 and 5%). The properties tested include bulk density, stability and flow of the concrete mix. The obtained optimum proportion of the modifier is 3%. It is found to enhance the stability, decrease the density and slightly decrease the flow of bituminous concrete sample. Conclusions from this study suggest that plastic modifier deals good engineering properties and its utilization as bitumen modifier could serve as a means of dealing the waste threat.

Keyword— Bitumen, Waste Plastic, Marshall Mix design

I. INTRODUCTION

The utilization of waste plastic materials has received a great improvement due to itsplentiful supply and high resistance to insects, fungi, animals, as well as molds, mildew, rot and many chemicals. However the dumping of the waste plastic materials in huge amounts has been a problem all over the country. These waste plastic break down in fire and form hazardous smoke, and toxic fumes or ash, typically comprising hydrogen cyanide. Burning waste plastic to recover the high energy used to create them is generally costly, so most of this waste plastic reaches the garbage dumps, decomposing very slowly. Certain reprocessing is done on them, usually creating pellets for recycle in the industry, but this is done at a much lower scale.

The mixing up of these waste plastic materials with other bio-degradable organic waste materials in the waste of the urban areas is another problem. Thus, more research is require to be centered towards a superior way of managing these waste plastic materials, in order to eliminate the problems generally come across in the current disposal method. It is possible to find useful application for the waste plastic materials, there will be considerable scrap value for this waste product and so they will be gathered and sold by interested persons, in place of being scattered or thrown out in the waste bins or into the road side drains. Bituminous concrete is a combined material commonly utilized in construction projects such as highway, airports and parking lots. It contains of bitumen, used as a binder and mineral aggregate intermingled together, then put down in layers and compacted [1].The amount of aggregate in bituminous concrete mixes is usually 90 to 95 percent by weight and 75 to 85 percent by volume and they are primarily responsible for the load carrying capacity of a pavement. The bitumen is a viscoelastic material with appropriate mechanical and rheologicalproperties for waterproofing and protecting coverings for roads and roofs, because of its better adhesion properties to aggregates [2, 3, 4, and 5]. Normally, the binder comprises 5 to 10 percent by weight of the concrete blend and various grades like 30/40, 60/70 and 80/ 100 are available on the basis of their penetration values. The performance of the road pavement is mainly influenced by the properties of the bituminous binder as bitumen [6]. Though, Roads formed with bitumen binders are exposed to many tough environmental conditions such as heavy traffic loading, entrance of water, chemical attack and widely changing temperatures. Normal bitumen frequently cannot provide the required resistance to these circumstances so modification of the bitumen properties becomes essential. Though, some improvements in bitumen properties have been achieved by selecting the proper starting crude to make bitumen. Unluckily, there are only a few crudes that can produce better bitumen suitable for paving applications [6, 7]. However, practical experience over the last four decades has made known that the modification of the bitumen binder with polymer additives, deals numerous benefits. These contain improved adhesion and cohesion properties, improved fatigue resistance, improved thermal stress cracking, and reduction in temperature susceptibility and reduction of rutting [8, 9, and 10]. As a result, bitumen modified with polymers is a common means of providing optimally performing pavement. This work goals to determine the influence of polythene modified bitumen on the properties of bitumen mix.

II. MATERIALS AND METHODS

The materials used for the purpose of this research were Waste Plastic, Bitumen (VG 10), and Aggregates. Waste plastic materials were collected from the canteens of residential hostels. The collected waste plastics were sorted, de-dusted, washed when necessary and sun-dried for few days until all the samples were dry. The dried samples of the waste plastic materials were shredded into sizes between 0.6mm to 2.36mm in the shredding machine to enhance its surface area of contact with the bitumen during mixing. Normally, polymer use in bituminous concrete could be in form of aggregate or binder modifier. The modified bitumen was ready by heating bitumen with shredded plastic materials of sizes between 0.6mm to 2.36mm. Five proportion of plastic content (1.0, 2.0, 3.0, 4.0 and 5%) were considered.

Table1**.** Physical Properties of Waste Plastic

Specific gravity	0.92
Softening point	58.22℃
Young modulus	104.50 M Pa
Strain at break	1372%
Strain at peak	1282.6%
Displacement at break	149.14 mm
Displacement at peak	134.18 mm
Load at peak	0.0162 KN
Stress at peak	19.20 M Pa

Table 2. Physical Properties of Bitumen

Characteristics	Method of Test	Test Results
Specific Gravity	IS1202:1978	1.09
Softening Point (℃)	IS1202:1978	52
Penetration25℃ (mm)	IS1202:1978	92
Ductility	IS1202:1978	85

Volume 4 Issue IV, April 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Table 3. Physical Properties of Aggregate

Properties	Unit	Method of test	Test Value
Properties of Coarse Aggregate			
Bulk Specific Gravity	--	IS: 2386(1)	2.68
Apparent specific gravity	--	IS: 2386(1)	2.72
Impact value	%	IS: 2386(1)	18
Flakiness and elongation index	%	IS: 2386(1)	40
Properties of fine aggregate			
Bulk Specific Gravity	--	IS: 2386(1)	2.68
Apparent specific gravity	--	IS: 2386(1)	2.72
Angularity number	--	IS: 2386(1)	49
Plasticity index	--	IS: 2720	NP

The mixture was constantly steered until a uniform mix was achieved at 265^{o}C. The coarse and fine aggregates used were crushed granite and sand materials respectively, fly ash were used as filler materials. Sieve analysis was done using mechanical shaker. The sieve sizes range between 0.075mm to 19mm. The weight retained on each sieve was noted. Percentage passing each size was calculated.

Table4. Aggregate Grading for Bituminous Mix

Sieve Sizes (mm)	Percent passing by weight (Specified)	Percentage passing, By weight (Adopted)
19	100	100
13.2	79-100	96
9.5	70-88	86
4.75	53-71	54
2.36	42-58	50
1.18	34-48	46
0.6	26-38	36
0.3	18-28	25
0.15	12-20	14
0.075	4-10	6

Trial mixes were made to combine the coarse and fine aggregates to find all combined grading satisfying the specification. In order to determine the effect of modified binder on the properties of bituminous concrete, it is essential to carry out mix design to find out the optimum bitumen content for the mix using unmodified bitumen as the binder. Three samples were utilized to make bitumen mixtures with one bitumen content. The average values of three samples for the Unit Weight, Bulk Specific Gravity, Marshall Stability and Flow properties for each binder content was found out. Six binder contents were considered (3.5, 4, 4.5, 5, 5.5 and 6%). All examined bitumen concrete mixes wereprepared in accordance with the standard 75-blows. Density and Bulk Specific Gravity of specimens
of compacted asphalt mixtures were find out inaccordance with AASHTO T 166.

The Marshall Stability and Flow test was completed to find out the Marshall stability and Flow values of bituminous mixture as per ASTM D 6927-06. Optimum bitumen content was arrived at in the following procedures:

A. The following graphs were plotted
1) Bulk density content vs. Bitumen content
2) Marshall Stability vs. Bitumen content.
3) Flow vs. Bitumen content.

B. Optimum bitumen content satisfying the maximum stability and bulk density, as well as therequired minimum air void was selected from the graphs.

C. The modified binders (1, 2, 3, 4 and 5%) were utilized to prepare five samples of bituminous concrete according to the mix design following the standard processes explained above. The modified binders were added at optimum bitumen content for all the specimens and the sampleswere tested for Marshall Stability, Flow and Density to detect the effect of polythene modified binder on the properties of the specimen.

III. RESULT AND DISCUSSION

A. Marshall Mix design result

Marshall Samples were collected by changing the binder content and then we tested for its volumetric properties. We test the sample in Marshall testing machine and find Marshall Stability Value and flow value. Optimum binder content is selected as the average binder content for maximum density, maximum stability and certain percent air voids in the total mix. We found that optimum bitumen content is 4.5%.

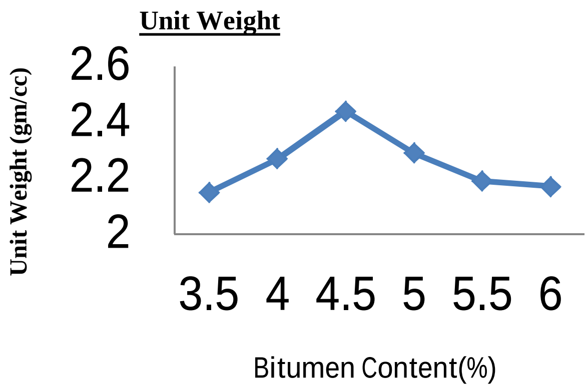

Figure 1. Unit Weight vs. Bitumen content

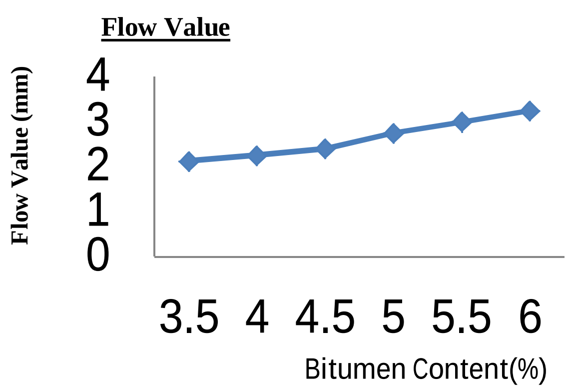

Figure 2. Flow Value vs. Bitumen content

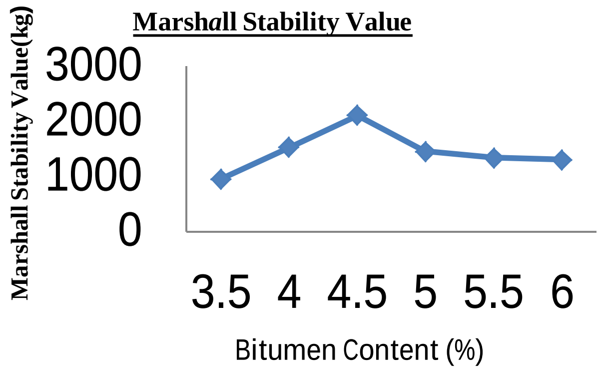

Figure 3. Marshal Stability Value vs. Bitumen content

B. Effect of plastic modified bitumen on the properties of bituminous concrete

After find the optimum bitumen content, we observe optimum plastic content at optimum bitumen content.It indicated that Marshall Stability value grows with plastic content up to 3% and after that it reduces. We note that the Marshall Flow value and unit weightfalls upon addition of plastic.

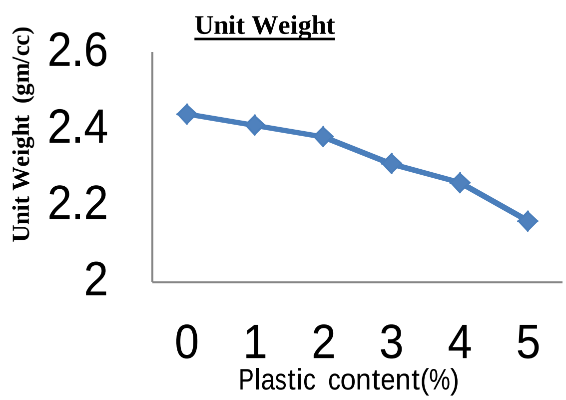

Figure 4. Unit Weight vs. Plastic content

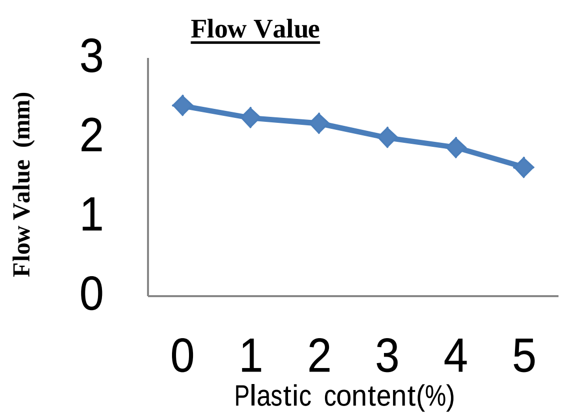

Figure 5. Flow Value vs. Plastic content

Volume 4 Issue IV, April 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

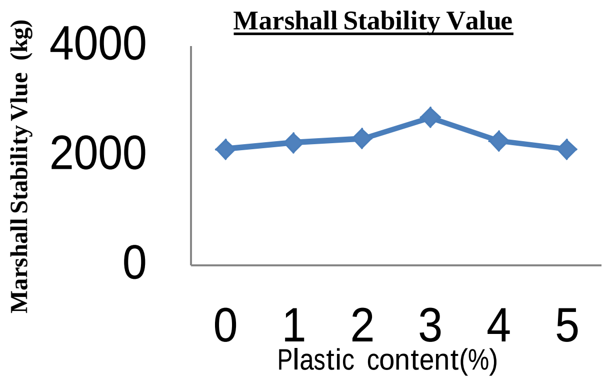

Figure 6. Marshal Stability Value vs. Plastic content

C. UNITS

1) kg represents kilogram
2) mm represents the millimeter
3) g/cc represent gram per centimeter cube

IV. CONCLUSION

The tests proceeded in two stages. Firstly, bituminous concrete mix design was completed to find out the optimum bitumen content for the blend. Secondly, modified binder prepared by mixing bitumen with waste plastic at various percentages, was utilized to make bituminous concrete specimen. The samples were tested to detect the effects of the modified binder. Testing and observation of the bituminous concrete prepared from polythene modified binder concluded that:

A. The unit weight of modified bituminous mix is lower than that of the control due to low density of the plastic.
B. The waste plastic utilized in the mix will get covered over aggregates of the mixture and increases the binding property and reduces porosity, absorption of moisture.
C. The flow value for modified bituminous concrete reduces with increasing plastic content.
D. The Marshall Stability Value is growing with a maximum increase percent of 27.27% as compared to Conventional mix when modified with 3% Plastic Waste
E. The Marshall Stability value increases with plastic content up to 3% and thereafter it decreases.
F. The optimum plastic content is 3%.
G. The improvement in stability of modified bituminous concrete is due to increase cohesion and adhesion properties of the binder will increase higher fatigue resistance, decrease thermal stress cracking, and reduce temperature susceptibility and decrease of rutting.

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