IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Study On The Strength Behavior Of Bituminous Mixes Incorporating Waste Plastics

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Abstract: Bituminous binders used in pavement construction works include both bitumen and tar. Bitumen is hydrocarbon material of pyrogenous origin, made available as by product of fractional distillation of crude petroleum. Bituminous materials are very commonly used in highway construction because of their binding and their water proofing properties. Plastic has become common man's friend. It finds its use in every field. Nearly 50% of the plastic consumed is used for packing. The most used plastic materials for packing are carry bags, cups, thermocoles and foams. These materials are manufactured using polymers like Polyethylene, polypropylene and polystyrene. The tubes and wires are made of poly vinyl chloride. These materials, once used are either thrown out or littered and ultimately get mixed with Municipal Solid Waste (MSW). As the plastic is non-biodegradable, its disposal is a problem and it causes social problems contributing to environmental pollution. Especially pollution caused by plastic is a very critical problem of the present society. In the present research work, the plastic blended bituminous mix using `Zycothermal` a chemical stabilizer is prepared by replacing optimum bitumen content with 8%, 10%, and 12% of plastic by weight of bitumen and Marshall Stability and flow values are compared with straight run bituminous mix.

Index Terms - : Bitumen, Plastic, Marshall Stability.

I. I NTRODUCTION

A good roadway infrastructure is the backbone of a strong stable economy. Over the years after independence there has been an extensive development of the road network across the length and breadth of India. As the modern highway transportation has high speed, high traffic density, heavy load and channelized traffic, asphalt concrete continues to reveal various types of distress. The causes for failure may be structural failure, climatic conditions as well as environmental factors and disintegration of paving materials due to weathering. Plastics have become common man's friend. It finds its use in every field. Nearly 50% of the plastic consumed is used for packing. The most used plastic materials for packing are carry bags, cups, Thermopolis and foams. These materials are manufactured using polymers like Polyethylene, polypropylene and polystyrene. The tubes and wires are made out of poly vinyl chloride. These materials, once used are either thrown out or littered and ultimately get mixed with Municipal Solid Waste (MSW). As the plastics are non- biodegradable, their disposal is a problem and they cause social problems contributing for environmental pollution. Especially pollution caused by plastic is a very critical problem of the present society.

Studies on stability, flow and volumetric properties of Plastic blended bituminous mix revealed that by adding plastic showed varied result which is as follows: Generally, Stability increases because addition load is carried by the plastic. In some cases the stability decreases because more plastic reduce the contact point between the aggregate. Flow decreases because flow (deformation) is resisted by plastic. In some cases the flow increases. Air voids increases because plastic absorbs binder needed to coat the aggregate there by introduces a air gap between aggregates. The plastic content is important parameter with respect to stability and volumetric Properties. But the Studies by varying the plastic content are limited. Studies on the effect of binder content on plastic parameters are not reported. In most cases, the blending of plastic has not been importance. The use of plastic improves the stability of bituminous mixes. But its effect on other property of the mix is not reported.

II. OBJECTIVES OF THE WORK

The present study is aimed at the study of influence of plastic on strength characteristics of plastic blended bituminous mixes. The objectives of the present study are: To study the Stability, Flow and Volumetric properties of the plastic blended bituminous mixes. To obtain an optimum plastic content to be used in plastic blended bituminous mixes. To study the cost effectiveness of plastic blended bituminous mixes.

III. MATERIALS AND METHODOLOGY

Following are the materials which are used in the present study:

Properties of bitumen:

Description of the Test	Test result	Requirement as per MORTH specification (Reference IS-73)
Penetration Test(mm)	69	65
Specific gravity	1.02	Min 0.99
Softening point (°C)	51	45 to 55
Ductility test (mm)	>100	Min 75
Flash point(^{0}C)	175^0 C	-
Fire point(^{0}C)	180^{0}C	-

Details of variables and the number of Specimens

Bitumen Content (%)	Plastic Content (%)	No. of specimens
5	0	3
	8	3
	10	3
	12	3

Proportioning of Aggregates:

After selecting the aggregates and their gradation, proportioning of aggregates has to be done and following are the common methods of proportioning of aggregates:

1. *Graphical Methods*: Two graphical methods in common use for proportioning of aggregates are Triangular chart method and Rothfutch's method.
2. *Trial and error procedure*: The proportion of materials is varied until the required aggregate gradation is achieved.

From the results it was observed that the specimens prepared has sufficient air voids and satisfies the MORTH requirements (3% to 6%).Hence the proportions and the bitumen content are finalized and consider as the reference mix.

IV. RESULTS AND DISCUSSIONS

The properties of semi dense bituminous concrete such as stability, flow, air voids (VV), Voids in mineral aggregate (VMA), voids filled with bitumen (VFB), unit weight and bulk specific gravity obtained from Marshall method of mix design were computed, analyzed and presented for both reference mix and plastic blended bituminous mix. Computation of the Optimum Plastic Content using the Marshall procedure is also presented.

Bituminous Mix Without Plastic (Reference Mix)

Specimens prepared without plastic were considered as reference specimens. The binder content of 5% (by weight of the mix) was used to prepare Marshall Specimens. Three specimens were prepared with this binder content. Specimens were tested as per ASTM D 1559. Mix properties like stability, flow, air voids (VV), Voids in mineral aggregate (VMA), Voids filled with bitumen (VFB), unit weight and bulk specific gravity were computed and presented below:

Properties of Bituminous Mix without Plastic

Bitumen Content (%)	Stability (Kg)	Flow (mm)	Unit Weight (gm/cc)	Air Voids (%)	VMA (%)	VFB (%)
5	2812.5	2.1	2.41	3.45	15.30	77.39
	2718.75	2	2.42	2.98	14.87	79.94
	2406.25	2.6	2.43	2.73	14.65	81.30

Bituminous Mix With Plastic

Test Specimens were prepared by adding plastic. The binder contents 5%(by weight of specimen), were used to prepare Marshall Specimens. Plastic content(8%, 10% and 12% by weight of bitumen) was added by replacing it with bitumen. Three specimens were prepared for every plastic content. Nine Specimens were tested as per ASTM D 1559. After pretest observation, stability, flow, air voids, Voids in mineral aggregate, voids filled with bitumen, unit density and bulk specific gravity were computed and presented below:

Properties of plastic blended bituminous mix

Binder content (%)	Plastic content (%)	Stability (KN)	Flow (mm)	Air Voids (%)	VMA (%)	VFB (%)	Unit Density (gm/cc)
5	8	2718.5	2.2	2.86	14.76	80.62	2.42
		3218.75	4	3.26	15.11	78.40	2.41
		3634.38	4.3	4.61	16.30	71.68	2.38
	10	2000	3	3.06	14.94	79.49	2.42
		3062.5	4.4	5.61	17.18	67.32	2.35
		2443.75	2.7	4.62	16.31	71.65	2.38
	12	2000	3.5	5.29	16.90	68.67	2.36
		2968.75	3.4	4.27	16.00	73.28	2.39
		2156.25	3.4	5.44	17.03	68.01	2.36

Computation of Optimum Plastic Content in the Bituminous Mix

The optimum plastic content was computed by taking the average of all binder corresponds to maximum stability and unit weight, minimum flow, mean air voids, mean VFB and mean VMA. Corresponding to that optimum plastic content stability, flow, air voids, VFB, VMA, unit weight and binder content were read from the graph. The optimum plastic content and the corresponding properties were presented below:

Computation of optimum plastic content

Binder content (%)	Plastic content (%)	Stability (Kg)	Flow (mm)	Air voids(%)	VMA(%)	VFB(%)	Unit weight (gm/cc)
5	8	3190.62	3.5	3.58	15.39	76.90	2.41
	10	2502.08	3.36	4.43	16.14	72.82	2.38
	12	2375.0	3.43	5.0	16.64	69.98	2.37
Max stability, max flow, mean VV, mean VFB, mean VMA and max unit weight		3190.62	3.5	4.34	16.06	73.23	2.38
Plastic Content(%)		8(a)	8(b)	10(c)	8(d)	8(e)	10(f)
Optimum plastic content		8.6					

Comparison of the Properties of Reference Mix and Plastic Blended Bituminous Mix

The properties and the optimum values of plastic blended bituminous mix were compared with the properties of reference bituminous mix by varying the plastic content. The mean values of stability, flow, air voids, Voids in mineral aggregate, voids filled with bitumen and unit weight of plastic blended bituminous mix were compared with the properties of reference bituminous mix by varying in plastic content. It was initially observed that the stability values were much higher, when compared with the reference mix because the plastic provide additional friction resistances between the aggregates..The maximum flow was due the smooth surface texture of plastic and the flow value decreases because of the excess binder which causes displacement used to coat the plastic. The air voids and voids in mineral aggregate was much higher and the voids filled with bitumen was lower than the reference mix because the excess binder which fills the air voids were used to coat the plastic and also plastic occupies in between the aggregates thereby increasing the air voids and reduces the voids filled with bitumen . The unit weight for the plastic blended bituminous mix was much lower than the reference mix because the plastic occupy in between the aggregates thus providing additional air voids thereby the unit weight gets reduced. The optimum values obtained for bituminous mix and plastic blended bituminous concrete were compared and presented below:

Comparison of the Reference Mix With Plastic Blended Bituminous Mix.

Optimum percentage and Properties	Without plastic	With plastic	Percentage variation (%)
Optimum plastic content (%)	0	8.6	-
Stability (kg)	2645.833	3190.625	+20
Flow (mm)	2.23	3.5	+0.57
Air voids (%)	3.06	4.36	+42.48
Voids in mineral aggregate (%)	14.94	16.05	+7.43
Voids filled with bitumen (%)	79.54	73.23	-7.93
Unit weight (gm/cc)	2.42	2.39	-1.24

It was observed that the addition of plastic favorably enhance the properties of bituminous mixtures by increasing the stability by 20% This was mainly because of the additional friction resistances provided by the plastics occurring in flexible road pavement due to traffic loads. The addition of plastic in the bituminous concrete increases the air voids and voids in mineral aggregate by 42% and 7% respectively. But decreases the Voids filled with bitumen by 7%. This was because more surface areas (aggregates and plastic) was to be coated by bitumen. In addition, plastic blended bituminous mix experience lower compatibility, leading to higher air void values. The unit weight decreased by 1.24%, because of the higher air voids. Thus the number of passes made by the roller in the field can be reduced.

V. cONCLUSIONS

The below conclusions are drawn from the experimental investigated

- The addition of plastic enhances the properties of bituminous mixtures by increasing its stability and flow at 8% of plastic. On further increasing of the plastic content upto 12% the stability and flow decreased. Therefore the optimum plastic content to be used is 8%. This makes the semi dense bituminous concrete acquiring the potential to improve structural resistance to distress occurring in flexible road pavement due to traffic loads.
- The voids increase with the increase in plastic content. The increase in the voids is significant in hot regions where bituminous mix is prone to bleeding. Increase in voids provides more spaces for the binder to move and prevents it from raising to the surface.
- It is concluded that the use of plastic in Bituminous mix significantly enhance the resistance of bituminous layers to tensile stress.

This method is important because it provides a solution to the major environmental problem i.e. usage of plastic by showing an alternative for it. It is more concerned about increasing the road's strength. So using these types of new technologies will help the society to be strong, clean and green.

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