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Review Paper on Use of Different Types of Additives In DBM (Dense Bitumen Macadam)

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Abstract

This paper summarizes the ongoing researches about the use of different types of additives in dense bitumen macadam (DBM). Many researches regarding the addition of additives have been laid down by different scholars. Many studies regarding the addition of polymer crumb rubber and waste materials like discarded tube tyres, plastic bottles and rice husk ash were studied and then their effects were also analyzed and laid down to a proper conclusion. It was concluded that by use of different types of additives in DBM increase the life of pavement, increased marshal stability values, lowered pavement deformation, increase fatigue resistance, provide better adhesion between asphalt and aggregates and increase in durability of original asphalt.

Keywords

Polymer crumb rubber, plastic bags, poly-ethylene, tyre rubber, glass powder and waste plastic, stability value and flow characteristics.

I. Introduction

The quality of roads dictates the economy of a country and hence the quality of our lives. Roads are vital for the transport of the goods and passengers. In India, road transport carries approximately 85% of passenger traffic and 70% of freight transport. But the construction of highways involves huge amount of the investment and mainly sixty percent of the highway project cost is associated with the pavement construction. Pavement isa durable surfacing of a road, airstrip, or similar area and the primary function is to transmit loads to the sub-base and underlying soil subgrade. Around ninety percent of the Indian Highways have a covered surface with bituminous layers which are constructed and maintained by using naturally available road aggregates and bitumen, a petroleum product, which being mixed at high temperatures to produce hot mix asphalt. Mix design for the different layers of the pavement can have a major impact on the performance, cost and sustainability of the bituminous surfaces. The need hence arises in making comprehensively efficient flexible pavements that may serve as an asset to the economy of a nation. In India, various techniques have been put forward in the field of highway engineering. There is hence an utmost urgency in bringing about more new ideas in this aspect so that a nation that is dependent mostly on its highways may pursue towards a better tomorrow.

II. Functions of Different Highway Materials

Fine Aggregates

Fine aggregates for DBM consists of crushed or naturally occurring mineral material or a combination of the two, passing the 2.36mm Indian standard sieve and retained on the 75 micron Indian standard sieve. Aggregates should be clean, hard, durable, and free from dust, dry and soft or friable matter, organic or other deleterious matter.

Coarse Aggregates

The coarse aggregates for the DBM mix consists of crushed rock, crushed gravel or other hard material retained on the 2.36mm sieve. Aggregates should be clean, hard, and durable, of cubical shape, free from dust and soft or friable material, organic or other deleterious matter. Where the Contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the permission of that source, the bitumen shall be treated with an approved anti -stripping agent, as per the engineering's recommendations, without additional payment.The aggregates should satisfy the physical requirements as specified in Table 3 (Ref: MOSRT&H Specifications for Road and Bridge Works (Fourth Revision) for Dense Bituminous Macadam.). Further specifications of ingredient aggregates are given in Table 1

Bitumen

The bitumen for the DBM is a paving bitumen of penetration Grade complying with Indian Standard Specifications for "Paving Bitumen" IS: 73, and of the penetration specified by MOSRT & H Specifications for Road and Bridge Works (Fourth Revision) Re-print March 2007 for Dense Bituminous Macadam.

Additives

Additives that can be added are: - Plastic bottles, polythene, tyre, polymers, rubber, glass, Plastic waste, Rice husk Ash, CRMB (crumb rubbermodified bitumen).
The requirements for minimum per cent voids in mineral aggregate (VMA) should be as per Table 4 and Requirements of DBM Mix [MORTH, Clause 507.3.1] are shown in Table 2.

Table 1: Specification of the Ingredient Aggregates.

Property	Specifications
Aggregate Impact Value, %	Maximum 27
Abrasion value%	Maximum 35
Flakiness and Elongation Indices, %, (Combined)	Maximum 30
Water Absorption, %	Maximum 2
Specific Gravity	-

Table 2 : Requirements of DBM Mix [MORTH, Clause 507.3.1]

MINIMUM STABILITY (KN AT 60DEGREE C)	20.25
MINIMUM FLOW(mm)	3
MAXIMUM FLOW(mm)	6
COMPACTION LEVEL (NUMBER OF BLOWS)	112 BLOWS ON EACH OF TWO FACES OF THE SPECIMEN
PERCENT AIR VOIDS	3-6.
PERCENT VOIDS IN MINERAL AGGREGATE(VMA)	As PER TABLE 1.5 BELOW
PERCENT VOIDS FILLED WITH BITUMEN (VFB)	65-75

Table 3 : Physical Requirements of Coarse Aggregate for Dense Bituminous Macadam [MORTH, Clause 507.2.2]

PROPERTY	TEST	SPECIFICATION
CLEANESSS	GRAIN SIZE ANALYSIS	MAX 50%PASSING O.075MM SIEVE
PARTICLE SHAPE	FLAKINESS AND ELONGATION INDEX	MAX 30%
STRENTH	LOS ANGELES ABRATION VALUE AGGREGRATE IMPACT VALVE	MAX 35% MAX 27%
DURABILITY	SOUNDNESS SODIUM SULPHATE MAGNESIUM SULPHATE	MAX 12% MAX 18%
WATER ABSORPTION	WATER ABSORPTION	MAX 2%
STRIPPING	COATING AND STRIPPING BITUMEN AGGREGATE MIXTURE	MINIMUM RETAINED COATING 95%
WATER SENSTIVITY	RETAINED TENSILE STRENGTH	MIN 80%

Table 4 : Minimum Percent Voids in Mineral Aggregate [MORTH, Clause 507.3.1]

NOMINAL MAXIMIUM PARTICLE SIZE	MINIMUM VMA PERCENT RELATED TO DESIGN AIR VOID PERCENT		
	3 %	4%	5%
9.5	14	15	16
12.5	13	14	15
19	12	13	14
25	11	12	13
37.5	10	11	12

III. Status of Ongoing Researches

1. Use of Plastic Waste in Bituminous Mixes

In 2002 plastic bags as an addition in bituminous concrete mixes were processed at Centre for Transportation Engineering of Bangalore University. The properties of the modified bitumen were compared with ordinary bitumen. It was examined that the penetration and ductility values of the modified bitumen decreased with the increase in proportion of the addition of plastic, up to 12 % by weight. Therefore the life of the pavement surfacing course using the altered bitumen is also expected to increase substantially in comparison to the use of ordinary bitumen. It was observed that the softening point of the modified bitumen increased with the addition of plastic additive, up to 8.0 % by weight. [1]

In 2008 waste plastic for modification of bituminous concrete was used. Marshall Method was adopted to find out optimum binder content. Marshall specimen were prepared for bitumen content 5,5.5,6,6.5 percent by weight of aggregate with 6%,10%,14% and 18% waste plastics by weight of bitumen. The Marshall Stability values increased by 18%, 45%, 18% for the mix with 10%, 14%, 18% waste plastics.[2]

In 2007 it was concluded that the modified mixture has a higher stability and VMA (Void in Mix Aggregate) percentage in comparison to the non-modified mixtures. This, in returns, would positively affect the rutting resistance of these mixtures. The air void contents of the altered mixtures are not far from that of the non-modified one. Air voids proportion around 4% is insufficient to make room for the expansion of asphalt binder to prevent flushing or bleeding or that would lower the skid resistance of the pavement and increase rutting awareness. In summary, using the poly-ethylene in asphalt mixture lowers pavement deformation; increase fatigue resistance and also provide better adhesion between the asphalt and the aggregates.[3]

In 2012 an attempt was made to use waste plastic, Crumb Rubber and Low Density Polyethylene (LDPE), blended using wet process for CRMB and dry process for LDPE. Marshal method of bituminous mix design was carried out for varying percentages of Crumb Rubber and LDPE to determine the different mix design characteristics. The study on the use of LDPE and CRMB confess that the Marshal Stability value, which is the stability parameter of SDBC has shown increasing trend. It is sufficient to help readers to be familiar with the different technologies applied of producing and incorporating modifiers in asphalt mixtures that are important in construction of roads with very qualified pavements and improved longevity and pavement performance.[4]

In 2010 an application of neural networks (NN) for the prediction of Marshall Test results for polypropylene (PP) modified asphalt mixtures was presented. PP fibers are used to adapt the bituminous binder in order to improve the physical and mechanical properties come from asphaltic mixture. Marshall Stability and flow tests were carried out on specimens fabricated with different kind of PP fibers and also waste PP at optimum bitumen content. It has been shown that the addition of PP fibers improved Marshall Stabilities and Marshall Quotient values.[5]

In 2012 the importance was to add the shredded waste plastic bottles to bituminous concrete (BC) mix and to calculate the various mix properties like Marshall Stability, flow, bulk density, voids in the mix and VFB. Also the effect of soaking conditions of the mix was investigated. Indirect tensile strength investigated for OBC and 8% plastic coated on aggregates which had yielded the highest marshal stability. The optimum plastic content for 60/70 and 80/100 grade bitumen was 8%. [6]

In 2009 the potential use of low density polyethylene (LDPE) as a modifier for asphalt paving materials was investiagted. Five different blends in addition to conventional mix were subjected to binder testing such as rheological tests, as well as to some other tests similar to the homogeneity of the system. Further, its effect on the moisture sensitivity and low temperature conduct of stone matrix asphalt (SMA) mixtures was studied. Research results indicate that modified binders showed greater softening point, keeping the values of ductility at minimum range of specification of (100cm), and caused a contraction in percentage loss of weight due to heat and air (i.e. increase durability of original asphalt). [7]

2. Use of Crmb in Bituminous Mixes

In 2009, crumb rubber altered bitumen (CRMB 55) was blended at specified temperatures. Marshall's mix design was carried out by changing the altered bitumen content at sable optimum rubber content and subsequent tests have been performed to resolve the different mix design nature and For conventional bitumen (60/70) also. This has resulted in much revised characteristics when analyses with straight run bitumen and that too at reduced optimum modified binder content (5.67%).[8]

In 2006 Marshall's mix design was borne out by changing the CRMB content at and subsequent tests have been carry out to determine the different mix design nature and concluded that the fatigue life, temperature susceptibility and resistance to moisture damage nature of the bituminous mixes can be improved by the use of CRMB as compared to other unmodified bitumen.[9]

In 2007 investigation was carried out on the usefulness of using Asphalt Rubber (AR) as a binder for SMA. They produced this AR by mixing ground tire rubber (GTR) with AC-20 asphalt. They describe it as AR-SMA. The performance of AR-SMA was evaluated, describes moisture awareness. It was found that the AR-SMA mixtures were not significantly different from the conventional SMA mixtures in terms of moisture awareness. It was also observed that no fiber was needed to prevent drain down when this AR is used in the mix.[10]

In 2005 Taguchi method was used to resolve optimum conditions for tire rubber in asphalt concrete with Marshall Test. The tyre rubber in asphalt concrete was examine under different experimental parameters including tire rubber gradation, aggregate gradation, mixing temperature, tire rubber ratio (0–10% by weight of asphalt), binder ratio (4–7% by weight of asphalt), and mixing time (5–30 min),compaction temperature (110–135^{0}C). The optimum conditions were obtained for tire rubber gradation (IS sieve #40), mixing temperature (155^{0}C), aggregate gradation (grad. 1), tire rubber ratio (10%), compaction temperature (135^{0}C), binder ratio (5.5%), mixing time (15 min).[11]

In 2010 investigation was carried to improve the mechanical properties of asphalt mixes, additives are added to the base asphalt binder. These binders are called altered asphalt binders. The objectives of the present study are to compare the performance of asphalt mixes with particular binders by two different mix design methods and to optimize the asphalt binder type to achieve the aspire performance. Two methods of mix design namely, Marshall and Super pave mix design methods are considered. The achievements of asphalt mixes viz., tensile strength, moisture damage, densification and rutting resistance were compared. The results determined a statistically significant difference in the optimum asphalt binder content from these mix design methods. Marshall Method of asphalt mix design is establishing to yield lower optimal asphalt binder content when compare to the Super pave method of mix design. The moisture susceptibility and construction densification index of asphalt mixes, conducted by using super pave method were found to be significantly lower than that of the mixes conducted by Marshall Method. Optimization by using a Mixed Integer Linear Program (MILP) indicated that the polymer modified asphalt binder exceed the conditions of engineering properties when compared to other commercial binders used in the study**.**[12]

3. Use of PMB in Bituminous Mixes

In 2007, polyethylene as one kind of polymers is used to investigate the potential prospects to enhance asphalt mixture properties. The objectives also comprise of resolving the best type of polyethylene to be used and its proportion. Two types of polyethylene were combined to coat the aggregate High Density Polyethylene (HDPE) and Low Density Polyethylene (LDPE). The results show that grinded HDPE polyethylene modifier provides better engineering properties. The recommended percentage of the modifier is 12% by the weight of bitumen content. It is found to increase the stability, reduce the density and increases the air voids and the voids of mineral aggregate.[13]

In 2004binder PG 76-22 was used as an achievement grade to study the SMA properties. Marshall's mix design was carried out by changing the bitumen content at constant and subsequent tests have been performed to determine the different mix design characteristics .They checked that polymer modified bitumen gives better performance (in terms of deformation) than unmodified bitumen.[14]

4. Use of Other Additives in Bituminous Mixes

In 1996 the outcome of mineral fillers on properties of SMA mixtures was studeid. They choose eight mineral fillers on the basis of their gradation, and performance etc. They calculate the properties of SMA mixtures in terms of drain down of the mastic, rutting, workability, low temperature cracking, and moisture sensitivity. [15]

In 2010 outcome of using waste glass power as mineral filler on Marshall Property of SMA by examine with SMA where ordinary Portland cement, lime stone was taken as filler with varying content (4-7%) was studied. Marshall's mix design was carried out by changing the, ordinary Portland cement content and lime stone by subsequent tests have been performed to determine the different mix design characteristics.[16]

In 1994 viscosity grade binder AC-20 was used on SMA properties related to mixture design. Marshall's mix design was carried out by changing the Binder Content and various numbers of tests have been performed to determine the different mix design characteristics.[17]

IV. Conclusion

After going through number of researches, I conclude that use of polymers crumb rubber and waste materials like discarded tube tyres, plastic bottles and rice husk ash in dense bitumen macadam (DBM) not only improves the quality of DBM but also helps in usage of these waste materials. The number of case studies supplied throughout this research was sufficient to help readers to be familiar with the different technologies applied of producing and incorporating modifiers in asphalt mixtures that are important in construction of roads with very qualified pavements and improved longevity and pavement performance.

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