

An Experimental Study on Modification of Dense Graded Bituminous Mix Design

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ABSTRACT

Various problems on the roads have been frequently observed on flexible pavements like: potholes, rutting, shoving etc. In hot and developing countries like India, roads are affected by several problems mentioned above, due to the water presence in the pavement, heavy traffic load, excessive no. of vehicles. Literature review lightens up on solution of these problems by modification of bitumen. To lighten this process, several measures may be effective, such as, use of better quality materials like waste plastic, motor oil, crumb rubber. This study proposes the utilization of waste materials i.e. waste plastic, crumb rubber and motor oil and check their suitability to mitigate these defects of cracking, rutting, pothole etc. Marshall stability method is chosen to determine the stability and flow value for bitumen mix design. Individual effects of polythene, crumb rubber and motor oil is analyzed first by varying the percentage of same with optimum bitumen content. And comprehensive effect of these three material has been also observed and discussed by plotting the graphs and it is found that Bitumen (5.5 %), Crumb Rubber (8%), Waste Plastic (6%) and Motor Oil (2%) gives highest stability and other properties values within the range given in MORTH. It is expected that this study would be useful to researchers and consultancies to construct the roads economically and long lasting servicing.

KEYWORD

DBM, Plastic, Motor Oil, Crumb Rubber, Mix Design

I. INTRODUCTION

At a very long time there is problem of releasing of fine aggregate particles. Strength and functional problems like cracks on road, flexibility, durability of

road is occur after some years. The normal roads are not more stable and resistible to the climate changes, therefore there is a need to mitigate these problems. Therefore, this study identifies need to improve the bituminous mix design to recover the problems mentioned above. Need to modify the property of bitumen by using this modifier. The use of waste polythene material has received a boost in the field of road construction. However the huge quantity of waste polythene disposal becomes a great problem to the country. Further increasing waste tyre disposal causes hazardous problems that lead environmental pollution. Therefore, use of waste tyre can be helpful in modification of bitumen mix in enhancing pavement life, driving comfort and low maintenance. Based on literature review it has been observed that the effect of bitumen modification using waste tyre is worth full but not at its full efficiency due to reduction in flow value of bitumen mix. Therefore, waste motor oil is introduced to enhance the lubrication property of bitumen mix, so that bitumen mix can be modified economically with its full efficiency. Thus, the effect of modifiers i.e. crumb rubber, waste plastic and waste motor oil is investigated in this study in comprehensive manner. Initially the effect of crumb rubber % is evaluated starting from 4% and increment is done by 2% and properties of bitumen mix are evaluated up to 10%. Results obtained from marshall stability is found that 8 % of crumb rubber gives better results in stability and within permissible limits defined by MORTH. Secondly the effect of plastic % is evaluated starting from 4% and increment is done by 2% and properties of bitumen mix are evaluated up to 10%. Results obtained from marshall stability is found that 8 % of plastic gives better results in stability and within permissible limits defined by MORTH. Thirdly the effect of waste motor oil percentage is evaluated starting from 4% and increment is done by 2% and properties of bitumen mix is evaluated up to 8%. Results obtained from

Marshall stability does not show improvement in stability. However, it is expected that comprehensive use of motor oil with rubber and plastic will improve the results. Finally variation of all modifiers are checked by conducting marshall stability test and it is found that Bitumen (5.5 %), Crumb Rubber (8%), Waste Plastic (6%) and Motor Oil (2%) gives highest stability and other properties values within the range given in MORTH. The main objective of the study is to analyse the performance of modified bitumen mix design by using motor oil, waste plastic, crumb rubber. To determine the relevant index and engineering properties of plastic waste, rubber tyre and compare them with conventional bitumen.

II. LITERATURE REVIEW

A typical literature is carried out on the modifying bitumen mix design by using various waste materials or combination of waste material. Magdy abdelrahman et.al. (2015) found that the utilization of UMO only as a modifier to asphalt severely deteriorates the macro and micro mechanical properties of the binder because the UMO disrupts the asphalt intermolecular associations and internal network structure, in the absence of CRM. Combining CRM with UMO as modifiers to asphalt had better results for the lower percentages of modifiers (10% CRM with 3% UMO). Niraj D.et.al. (2013). K. Rajesh Kumar (2014), Rishi Singh Chhabra et. Al. (2014) also studied on effects of crumb rubber and HDPE on bituminous mix design. Optimum substance of waste elastic tires to be utilized is between the scope of 5% to 20%. • Problem like warm breaking and perpetual distortion are diminish in hot temperature area. Use of waste polyethylene in HMA is relied upon to yield better and improved waste administration and better city cleanliness and environment. Athira R Prasad (2015) conducted a study by completing Marshall Test for control blend tests which was set up by including 5%, 5.5%, 6%, 6.5%, 7% bitumen by weight of total to shape BC blend, OBC was gotten as 5.1%. Addition of PET and elastic in 3%, 4.5%, 6%, 7.5% and 9% to BC blend tests keeping steady OBC. It was found that in every one of the three cases, the ideal substance was acquired as 6%.

III. FRAME WORK OF METHODOLOGY

Fig 1 shows that for proposed details of the steps involved in the frame work of proposed methodology and the detail of the steps are given as below in the subsections.

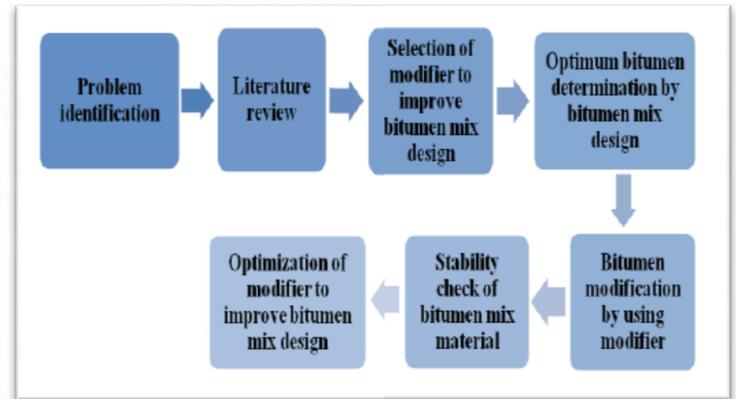


Fig 1:Frame work of proposed methodology

Steps Involved in Proposed Methodology

- Selection of modifiers to improve bituminous mix design
- Suitability check of bitumen mix material
- Optimum bitumen determination by bitumen mix design
- Bitumen modification by using modifiers
- Optimization of modifiers to improve bitumen mix design

IV. RESULTS AND ANALYSIS

A. Selection of modifiers to improve bituminous mix design

Crumb Rubber

Increasing number of four wheeler and two wheeler resulting huge amount of waste tyre that is disposed in rural as well as in urban areas. Disposed tyres are creating environmental hazardous problems by open burning tyres.

Waste Plastic

Waste plastics collected from households are washed, cleaned and dried. Polythenes shredded into small pieces in required quantities to blend with hot bitumen at 170- 1800 C for around 30 minutes. Percentage variation in terms of weightage of bitumen.

Waste Motor Oil

Waste motor oil is additional modifier is tried in this study to enhance flow value of bitumen mix. Understanding of decreasing value of flow value due to increase of crumb rubber fails the suitable results of Mix design.

B. Suitability check of bitumen mix material

TABLE I TEST RESULTS FOR AGGREGATE

Test	Sample 1	Sample 2	Average	Optimum value of test
Impact value	6.17	3.99	5.08	<35%
Elongation + flakiness index(%)	13.11	16.94	30.05	Combined <40%
Loss angeles (%)	10.84	13.04	11.94	<50%

TABLE III TEST RESULTS FOR BITUMEN

Test	Sample 1	Sample 2	Sample 3	Average
Softening point(°C)	48	51	53	50.33
Penetration (mm)	24.3	27.9	29.5	27.23
Ductility (cm)	47.4	49.7	-	48.55
Flash point (°C)	251	249	248	249.33
Fire point (°C)	266	263	261	263.33

C. Optimum bitumen determination by bitumen mix design

Dense Graded Bituminous Macadam grading has been selected in this study to modify the bitumen mix design. Aggregate Grading given in Table III is selected from MORTH- 500, 5th revision Specifications for DBM Grade. Bitumen having penetration grade 60/70 has been selected in this study, generally suitable for superior properties of flexible pavements. Marshal Stability Testing of Bitumen mix is used to check the properties of bitumen mix i.e. marshal stability, flow value, air voids etc.

Marshal test is used to determine the optimum

bitumen content for a designed bitumen mix. Optimum bitumen is the content of bitumen at which mix satisfies the mechanical and volumetric properties of bitumen mix. Fig 2 shows the process of marshal stability test from starting grading of aggregates to testing to determine stability and flow value.

TABLE IIIII TABLE OF GRADING OF AGGREGATE

Grading	1	2
Nominal aggregate size*	37.5 mm	26.5 mm
Layer thickness	75 – 100 mm	50 – 75 mm
IS Sieve (mm) Cumulative % by weight of total aggregate passing		
45	100	-
37.5	95 – 100	100
26.5	63-93	90-100
19	-	71-95
13.2	55-75	56-80
9.5	-	-
4.75	38-54	38-54
2.36	28-42	38-54
1.18	-	-
0.6	-	-
0.3	7 – 21	7 – 21
0.15	-	-
0.075	2 – 8	7 – 21
Bitumen content % by mass of total mix **	Min 4.0	Min 4.5



Fig 2: Bitumen Mix Design Process to Find OBC for DBM

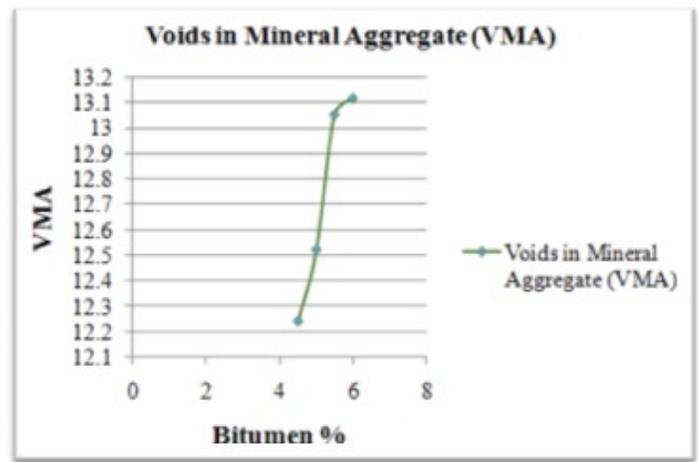
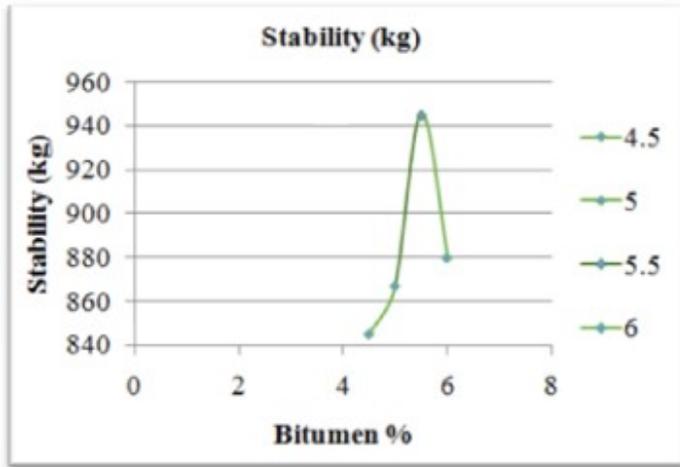


Fig 3 Graph showing Stability v/s Bitumen Content %

Fig 6 Graph showing VMA v/s Bitumen Content %

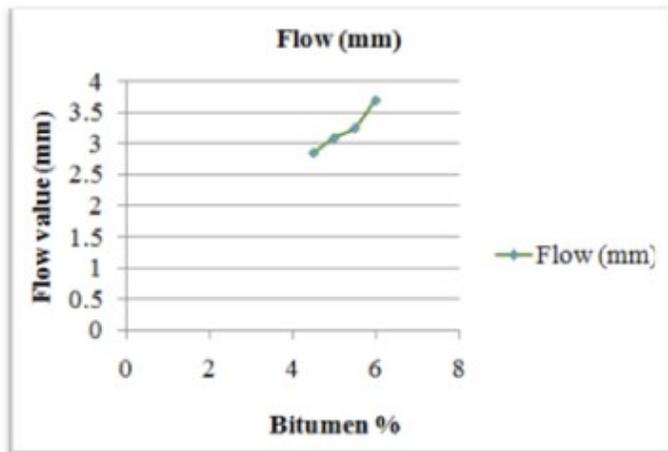


Fig 4 Graph showing Flow value v/s Bitumen Content %

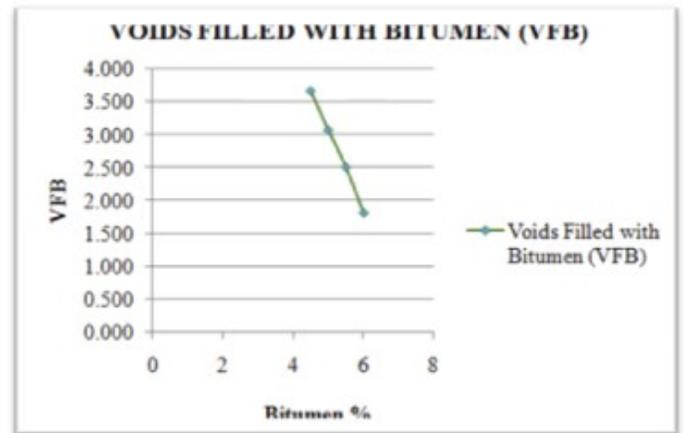


Fig 7 Graph showing VFB v/s Bitumen Content %

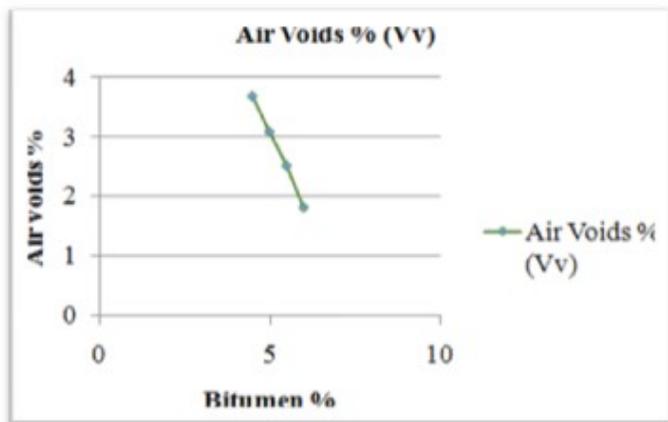


Fig 5 Graph showing Air Voids v/s Bitumen Content %

A bituminous mix sample is prepared by adding % of bitumen starting from 4.5 % to 6.0 %. The results of flow value and stability value is obtained and shown in the Fig3 and Fig 4 above. As per the graph plotted the flow value is increasing as the bitumen content increasing but stability value decrease after 5.5 % of bitumen content. Therefore from the graph Optimum Bitumen Content is found as 5.5 %.

D. Bitumen modification by using modifiers

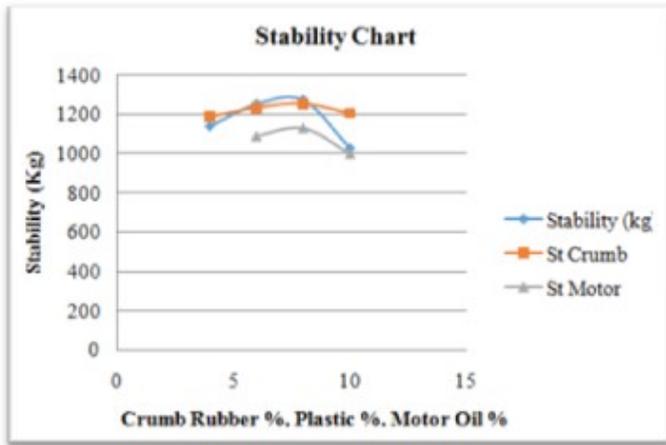


Fig 8 Graph showing marshal stability v/s modifiers: crumb rubber, plastic and motor oil

It is clear out from the graphs that with the variation of plastic, motor oil, and crumb rubber stability value changes. Crumb rubber is most effective in enhancing the stability value compared to motor oil and plastic.

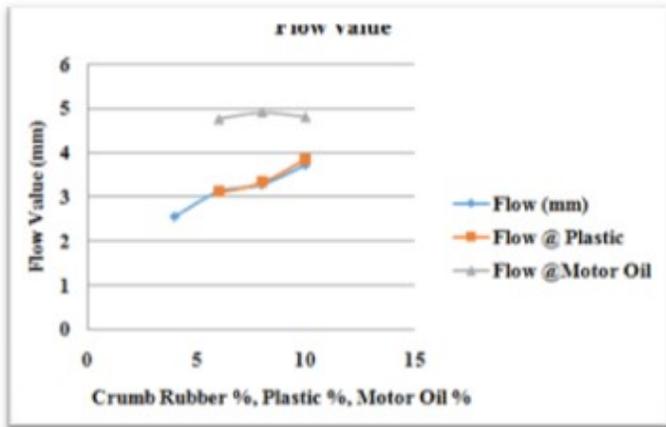


Fig 9 Graph of Flow value v/s modifiers

Flow value is higher with motor oil as compare to other materials and flow value increases with percentage of material.

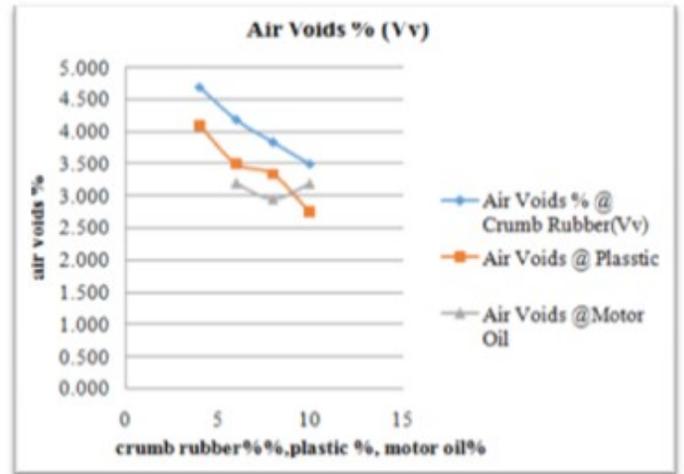


Fig 10 Graph showing air voids v/s modifiers: crumb rubber, plastic and motor oil

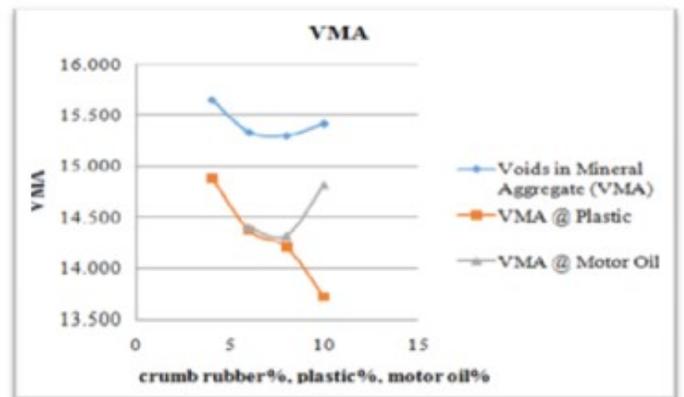


Fig 11 Graph showing VMA v/s modifiers: crumb rubber, plastic and motor oil

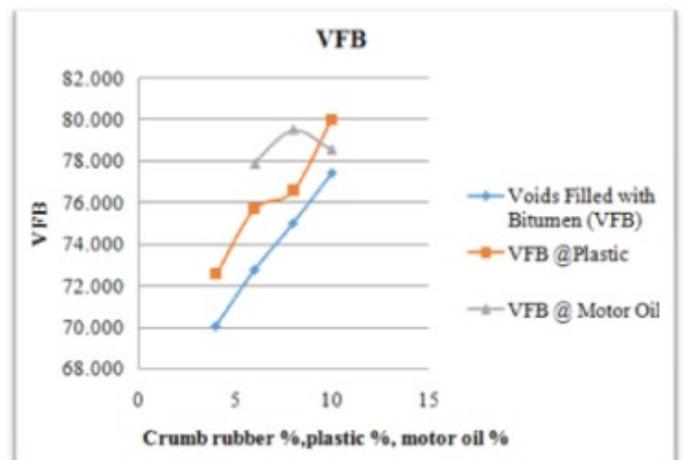


Fig 12 Graph showing VMA v/s modifiers: crumb rubber, plastic and motor oil

Finally variation of all modifiers are checked by conducting marshall stability test and it is found that Bitumen (5.5 %), Crumb Rubber (8%), Waste Plastic (6%) and Motor Oil (2%) gives highest stability and other properties values within the range given in MORTH. It is expected that this study would be useful to construction roads economically and ecofriendly.

V. CONCLUSIONS

In the road construction potholes, rutting, shoving are created due the environment problems. This problems can be mitigate by modifying bitumen. Based on literature review, it is found that comprehensive effects of rubber, motor oil and plastic have not been done. Therefore, this study proposed a methodology to improve the bitumen mix design by using combined modifiers waste plastic, waste motor oil, waste tyre crumb. Methodology consists total six stages. Determination of optimum bitumen is founded by conduct marshall stability which is 5.5% of total amount of aggregate. After optimum bitumen content, optimum percentage of modifiers would be found. Initially the effect of crumb rubber % is evaluated starting from 4% and increment is done by 2% and properties of bitumen mix are evaluated up to 10%. Results obtained from marshall stability is found that 8 % of crumb rubber gives better results in stability and within permissible limits defined by MORTH. Secondly the effect of plastic % is evaluated starting from 4% and increment is done by 2% and properties of bitumen mix are evaluated up to 10%. Results obtained from marshall stability is found that 8 % of plastic gives better results in stability and within permissible limits defined by MORTH. Thirdly the effect of waste motor oil percentage is evaluated starting from 4% and increment is done by 2% and properties of bitumen mix is evaluated up to 8%. Results obtained from Marshall stability does not show improvement in stability. However, it is expected that comprehensive use of motor oil with rubber and plastic will improve the results. Finally variation of all modifiers are checked by conducting marshall stability test and it is found that Bitumen (5.5 %), Crumb Rubber (8%), Waste Plastic (6%) and Motor Oil (2%) gives highest stability and other properties values within the range given in MORTH. It is expected that this study would be useful to construction roads economically and eco friendly.

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