IOSR Journal of Engineering (IOSR JEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
PP 01-09

Green Pavement

Aanandh N[1], Arjun Raghavan [2], Chandra Mohan K[2], Hariharan B[2], Mohamed Haisar Hayath[2]
[1]AssistantProfessor, [2]Final year students
Department of civil engineering, Rajalakshmi Engineering College

Abstract: *Generation of wastes and the energy required for it's recycling is increasing day by day. In order to cut down on the wastes and the energy required for recycling, one of the solutions is to make use of renewable resources or waste materials effectively. To fulfil this objective, the paper focuses on the utilization of wastes for laying Dense Bituminous Macadam (DBM). Plastics will be used as an additive thus enabling strength of bitumen added at the composition of 2.5% and 5% of the total weight of the core and fly ash will be a substitute for cement/stone dust at the composition of 5% and 10% of the total weight of the core. So we bring in the use of Dense Bituminous Macadam which is obtained from the removal of the existing DBM surface in order to lay a new layer. An overall comparison is made amongst the samples with the standard DBM as per MORTH. The comparison done is based on the results of tests like Marshall stability, Specific Gravity and Water Absorption which were carried out on the samples.*
Keywords*: Dense Bituminous macadam, Standard DBM, recycled DBM, fly ash, plastics.*

I. Introduction

Disposal of plastic is a great problem in present scenario due to its non-biodegradable nature and scarcity of landfills. Studies have revealed that it can be successfully utilized in the bituminous mixes of flexible pavements resulting in its better performance in terms of better strength, resistance to deformation and economy.Bituminous mixes used in flexible pavement construction includes bitumen (used as a binder) and mineral aggregate which are mixed together. The possible utilization of waste materials such as waste plastic and fly ash in bituminous mixes can provide a better solution for environmentally sustainable waste management. By using waste materials in road construction, it proves to be environment-friendly, economical, gives better strength and durability to the road. The main aim of using the waste plastic on bituminous mix study is to focus on using the waste/ recycled plastic materials present in bulk which can be used economically and conveniently. The use of fly ash as a filler material can be a better way for related disposal problem .Objective of our project is to provide a greener ,stronger and economical flexible pavement.

II. Literature

[1]*In 2011 Chandra et al* have assessed that the production of ash by 2030 will reach around 600 million tons. Studies have disclosed that the scope of using these ashes and other waste materials in highway sector are very much on cards as their effect on performance proves to be technically, economically and environmentally viable and acceptable and are within the prescribed norms and specifications.[2]As per *Kumar et al in 2008,* the waste materials like fly ash and plastic waste may be handily employed in the hydrocarbon mixes of versatile pavement construction thanks to their appurtenant and pavement friendly characteristics. The plastic are going to be answerable for rising some properties of the hydrocarbon combine and at a similar time can solve the environmental issues associated with its disposal similarly. It can be used as an economical mineral filler in bituminous concrete of flexible pavements and other asphalt paving applications.[3] *Brajesh Mishra et al in 2017* has concluded that fly ash plastic composites, Where fly ash can be used as fillers in BC mix and plastic as an additional binder.Moreover, the rutting failure, creep failure and cracks were reduced by the addition of fly ash plastic composites.

III. Materials And Methodology Used

3.1 Bitumen

The binder used in flexible pavement is bitumen. The black liquid that is extracted from the crude oil and which is also a costly resource available to us. Viscosity Grading (VG) 30 bitumen is used in our project.In India, most of the pavements are laid using this grade of bitumen since 2008. The bitumen is heated to 150-170^o C and then mixed with the heated aggregates.

3.2 Coarse aggregates

The DBM is prepared using varying sizes of aggregates in different proportions based on the job mix. The aggregates used are 20mm,12.5mm and 6mm, based on the Marshall mix design (Fig 2) .Thus empowering a dense coarse of DBM .Later part of the project adds recycled DBM for analysis (Fig1) .Both the aggregates are heated to 140-170 C and then mixed with the hot bitumen.

3.3 Fine aggregates

The fine aggregates used here is stone dust which passes through 2.36mm sieve. The fine aggregate used is manufactured sand (M-sand) for the purpose of filling the voids and providing strength.

Fig 1: Recycled DBM

Fig 2: Coarse aggregates

3.4 Fillers

The filler used in standard DBM is cement at a very low percentage.We have replaced cement with Class-C Fly ash.These are aggregates passing through the 0.3mm and 75-micron sieves.They help in reducing the voids and water percolation.

Fig 3: Polypropylene

3.5 Polypropylene

Plastics are added as admixtures to the pavement in improving flexibility and durability.The plastics are added at the rate of 2.5% and 5% of the total weight of the aggregates.Since polypropylene has melting point around 180-190^{o}C, it is preferred over polyethylene considering its merits in load bearing and durability properties. These are obtained from plastic cups, bottles, pads, etc. (Fig 3)

Fig 4: Fly ash

3.6 Fly Ash

The fly ash is used as filler in our pavement where it replaces the cement addedin the Std. DBM as per conventional job mix. It is added as 5% and 10%of the total weight of the aggregate. The Fly ash class C is preferred since it has more pozzolaniccharacteristics than class F (Fig 4).

Fig 5: Core preparation

To achieve study goals, implementation would include the following methodology

The literature review of previous studies which include revision of books, scientific papers and reports in the field of recycled plastics and fly ash in the asphalt mix.Study of Marshall Mix design for a Standard DBM mix as per MORTH.And identifying Optimum Bitumen Content (OBC) using Marshal Mix design procedure for the standard DBM . Furthermore identifying the effects of adding different percentages of waste plastic materials and fly ash on the bituminous mix properties comparing it with the conventional mix by using dry methods of blending.

Preparing the mix and core for each variation.And finally testing the prepared cores for its stability, flow, VFB, VMA and bulk density.

IV. Experiments

4.1 Aggregate Tests:

4.1.1 Specific gravity and water absorption test:

The test is conducted using pycnometer as per IS 2386(iv). The aggregates used are stone dust,6mm,12.5mm and 20mm. The apparent and bulk specific gravities of the aggregates are given below in the table 1. Similarly, the observed data like W1, W2 & W3 which are the dry weight, immersed weight and wet dried weight of the aggregates respectively will give us the water absorption values for the same, tabulated in table 2.

Table 1: Specific Gravity results

Result obtained		
Size of Aggregate	Bulk specific gravity	Apparent specific gravity
20mm	2.885	2.973
12.5mm	2.932	2.985
6mm	2.863	2.987
Dust	2.654	2.886

Table 2: Water absorption results

Size of Aggregate	Result Obtained
20mm	1.02
12.5mm	0.604
6mm	1.05
Dust	1.50

4.1.2 Impact Value test:

The test is conducted using impact testing machine as per IS 2386(iv). The aggregates used are 12.5mm and 20mm. These aggregates are tested to determine the toughness and thereby determining its quality as per the given standards. They lie well within the standards i.e less than 30%. The data are given in table 3.

Table 3: Impact Value results

Size of Aggregate	Result Obtained%
20mm	23
12.5mm	25

4.1.3 Flakiness and Elongation test:

The test is conducted using standard thickness gauge and length gauge as per IS 2386(1).For aggregates 20mm and 12.5mm.The shape test helps to determine workability and stability of the mix. Thus the combined value of both are given in table 4.The IRC standard for combined indices is not to exceed 30 %.

Table 4: Combined flakiness and elongation

Size of Aggregate	Result obtained%
20mm	28.10
12.5mm	27.20

4.1.4 Stripping Value test:

The test is conducted as per IS 6241using water bath the stripping value of bitumen from the aggregate is observed and noted in table 5. The principle of the test is by immersing aggregate fully coated with the binder in water maintained at 40^{o} C temperature for 24 hours. IRC has specified maximum stripping value of aggregates should not exceed 5%.

Table 5: Stripping value results

Size of Aggregate	Result obtained%
20mm	98
12.5mm	99
6mm	99

4.2 Bitumen tests:

Bitumen testing is done using bitumen Grade VG-30. The following tests are done using IS 1202, IS 1203, IS 1205, IS 1208. The bitumen tests such as penetration value, specific gravity, ductility and softening point values are determined and tabulated in table 6.

Table 6: Bitumen test results

Test conducted	Result obtained	Limits as per IS:2013
Specific gravity	1.073	-
Penetration	52.33mm	Min 45mm
Softening point	47.67^{o}C	Min 47^{o}C
Ductility	48 cm	Min 40cm

4.3 Standard DBM analysis :

The standard DBM is prepared as per MORTH revision 5 and MS-2.The pavement cores are prepared using different bitumen content 4.25%,4.5%,4.75%,5% and 5.25%.

The core is prepared using proper job mix for 20mm, 12.5mm,6mm, stone dust and fillers.The accurate values are added to the core and were heated to a temperature of 140-160 C and alongside the bitumen is also heated to about 150 C, proper mixing and placement into the heated mould are done and 75 blows are given.After 24hrs the cores are tested, The following tests are done.

1. Specific gravity and water absorption test.
2. Marshal Stability test.
3. Extraction test.

4.3.1 Specific Gravity and water absorption test:

This test is conducted to all the cores prepared and the results are tabulated.The cores dry weight, submerged weight and wet weights are taken, which W1, W2 and W3 respectively and thevalues of specific gravity and water absorption are determined. The values of specific gravity and water absorption helps us to determine the bulk density (g/cc) of std. DBM and Recycled DBM, which are given in tables 7 and 9.

Fig 6: Specific gravity and water absorption test apparatus.

4.3.2 Marshal Stability test:

The test is done to determine the flow and stability of the cores using the Marshall Stability Testing apparatus. The cores are heated in a water bath up to 60^{o} C for 30 mins and the cores are placed into ring setup. The stability and flow values are observed using the proving ring. The voids present are also determined from the data observed from this test. The data of stability, flow VA and VFB of std. DBM and recycled DBM are given in table 7 and 9.

Fig 7: Marshall stability test

4.3.3 Extraction test

This is a conventional test method used to determine the bitumen content from any bitumen pavement sample. This test is done using the centrifuge extractor apparatus. The sample is soaked in petrol for 60 mins and the centrifugal force is generated using the apparatus, the petrol washes away the bitumen and gives us the aggregates alone. The change in weight helps us to determine the bitumen content of the pavement. The result of the experiment on the recycled DBM gave us a bitumen content of 2.5% which is short of 2% to optimum bitumen content of a DBM as specified by the MORTH.

Fig 8: Extraction test apparatus

Table 7: Standard DMB test results

S.n	Nature of Test	Binder content by weight of the mix				
		4.25%	4.5 %	4.75%	5.0 %	5.25%
1	Stability (kg)	782	955	1015	1160	1140
2	Flow (mm)	2	3	3	4	4
3	Bulk density (g/cc)	2.517	2.530	2.532	2.589	2.526
4	Voids in total mix (%)	7.053	6.192	5.733	5.216	3.25
5	Voids filled with binder (%)	53.87	58.92	62.35	67.4	76.00

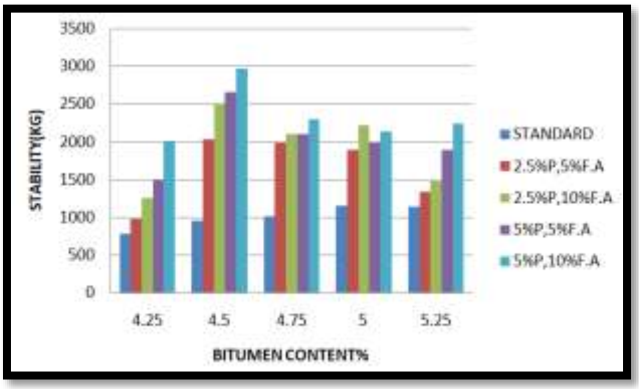

Fig 9: Stability (KG) vs Bitumen Content %

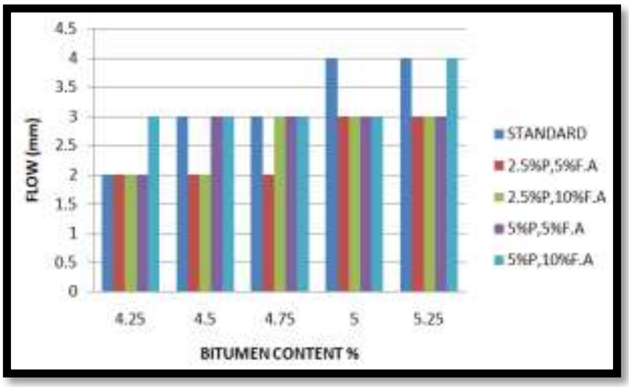

Fig 10: Flow (mm) vs Bitumen Content %

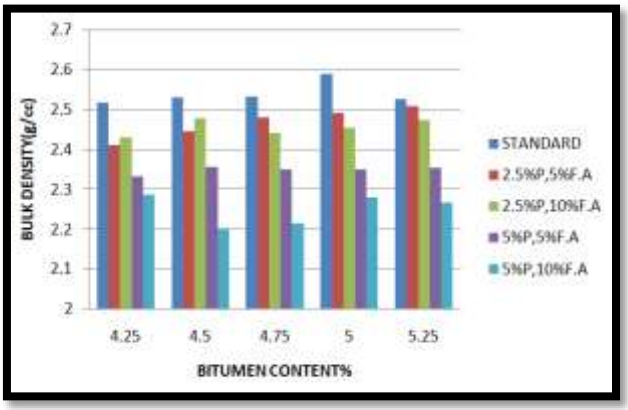

Fig 11: Bulk Density (g/cc) vs Bitumen content %

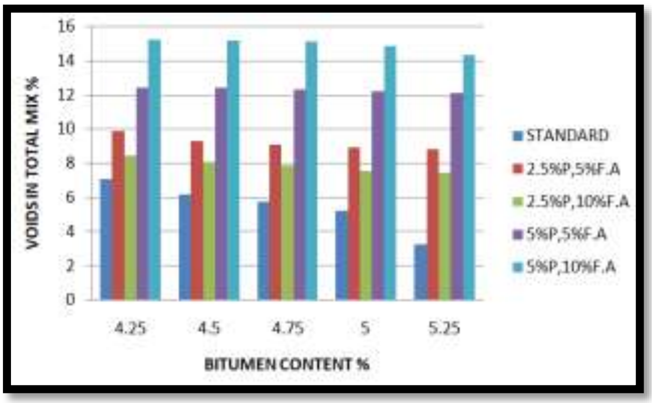

Fig 12: VA % vs Bitumen content %

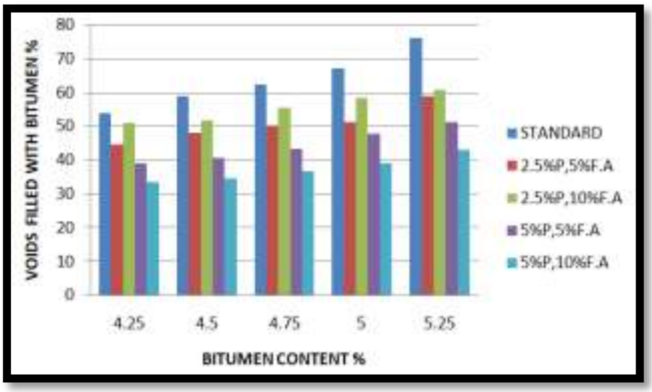

Fig 13: VFB% vs Bitumen Content %

V. Results And Discussion

The above figures 9 to 13 depicts the comparison between the standard DBM,2.5% of plastics and 5% of fly ash in the Recycled DBM ,2.5% of plastics and 10% of fly ash in the recycled DBM,5% of plastics and 5% of fly ash in the recycled DBM and finally 5% of plastics and 10% of fly ash in the recycled DBM. The Optimum bitumen content is determined for the standard DBM core which is equal to 5.06 %, given below in table 8. The corresponding standard DBM results for the corresponding OBC are shown in table 9.

Table 8: The optimum bitumen content

1	% of Bitumen content at Max Bulk density	5%
2	% of Bitumen content at Max Stability	5%
3	% of Bitumen content at 4% voids	5.15%
4	% Voids filled with bitumen at 70%	5.1%
5	% of Average Optimum Binder Content	5.06%

Table 9: Standard DBM results for OBC

S.no	Test parameters	Results
1	Stability (kg)	1146.24
2	Flow (mm)	4
3	Bulk density (g/cc)	2.558
4	Binder content by weight of mix (%)	5.06
5	Voids in total mix (VA) (%)	5.154
6	Voids filled with binder (VFB) (%)	67.94
7	Total aggregates by weight of mix (%)	94.94

Table 11 gives us the comparative tabular columns of the cores that we have tested, the core samples are represented using the IDs given during the testing which are briefed in table 8. The recycled cores use 100% reclaimed asphalt DBM.

Table 10: Core samples

Core ID	Description
C1	2.5% Plastic & 5% Fly ash
C2	2.5% Plastic & 10% Fly ash
C3	5% Plastic & 5% Fly ash
C4	5% Plastic & 10% Fy ash

Table 11: Plastics andFly ash in recycled DBM

S.no	Test Parameters	C1	C2	C3	C4
1	Stability (kg)	2034.5	2504	2660.5	2973.5
2	Flow (mm)	2	2	3	2
3	Bulk density (g/cc)	2.446	2.479	2.357	2.288
4	% of water absorbed by volume	1.43	0.24	1.05	0.96
5	Voids in total mix (VA) (%)	9.307	8.08	12.384	15.164
6	Voids filled with binder (VFB) (%)	47.989	51.843	40.689	34.629

Thus the comparative study of our recycled pavement samples to the standard pavement samples has been completed, and we have analysed that the cores we have created has better strength and flow but flexibility of the pavement can be questioned since the voids are quite more than the standard pavement, though increasing the fines in recycled DBM could help resolve the problem but more research is needed to be done so as to determine the job mix for the fines to be added in the pavement .

From the results obtained from our project, we can conclude that recycled DBM can be used as an alternative to the newly laid fresh DBM. The sample with 2.5% plastics and 10% fly ash in the recycled DBM with optimum bitumen content of 4.5% to the total weight of the aggregates gave us a better result ,why because on increasing the plastic content it was observed that the void content kept increasing than that of the standard's ,even though it had better strength the flexibility of the cores with higher plastics content dropped,2.5% plastic came out to be nominal and the fly ash of 10% to the total weight of the aggregate which replaced cement as fines and also contributed to the lost fine aggregates initially added in the pavement, aided in compromising the voids present. Since it is a DBM we are testing and not a Bituminous Concrete (BC) ,the strength and nominal flexibility as per standards is well regarded.

Thus our project has marked a significance for further research into the field of flexible pavement using recycled asphalt.Our choice of improving the quality of DBM proved a success. Still, this project could also aid in developing research in Wet Mix Macadam (WMM) and Bituminous Concrete (BC) layer of the flexible pavement. Since low energy is utilized for laying the recycled pavements and moreover reducing the cost and fresh natural resources to be used in pavements, This type of pavements can be renowned as green pavements and pave a way for sustainable development.

VI. Conclusion

The objective of the project to strengthen and to provide an economical and greener solution to the pavements has been achieved.Usage of wastes such as polypropylene and fly ash not only makes this project eco-friendly but also cost-effective as DBM scrapped can be reused along with the above-mentioned wastes without much use of bitumen. Since the need for fresh aggregates has eliminated the cost of transportation of these aggregates and the labour involved in this process can be significantly reduced. These type of pavements can be used where large scale DBM layer is necessary, provided there exists a pavement already which needs to be scrapped. Instead of hauling existing pavements and conveying newer aggregates, the existing pavement can be scrapped and then fresh bitumen is added to optimum and laid again, thereby recycling the pavement.This could help a country's economy and also in resources conservation.

Acknowledgement

We would like to thank our project guide and assistant professor Mr.Aanandh N for helping us by all means, our senior faculty and professor Dr Geetha S, department of civil engineering, Rajalakshmi Engineering College for motivating us to select the title and to proceed with our idea. Most importantly special regards to DAS MATERIAL TESTING PVT LTD., Chennai for accommodating us and helping us to perform various tests that required to prove and defend our proposal. One last thanks to my teammates from the batch TG for their dedication and hard work put in completing this project.

References

[1]. M Sharma V. and Chandra S. "Characterization of Indian fly ash for use in bituminous construction", Highway Research Journal, 2011, Vol-4, No.1,pp1-11.
[2]. Singh V., Mehindiratta H.C. and Kumar P. " Useof fly ash in the bituminous layer of pavement", Indian Highways, 2008, N0.8, pp 51-50.
[3]. Brajesh Mishra and M K Gupta "Use of fly ash plastic composite in bituminous concrete mixes of flexible pavement", American Journal of Engineering Research (AJER),2017, e-ISSN: 2320-0847 p-ISSN: 2320-0936, Volume-6, Issue-9, pp-253-262
[4]. IRC:111-2009, Specifications for Dense Graded Bituminous Mixes.
[5]. IRC: SP: 98-2013, Guidelines for the use of Waste Plastic in Hot Bituminous Mixes in Wearing Courses.
[6]. IRC: SP: 107. Guideline for Gap Graded Wearing Courses with Rubberized Bitumen (Bitumen - Rubber). Indian Road Congress. New Delhi, India. 2015; p. 1-28.
[7]. IS 1201 to 1220: Methods for Testing Tar and Bituminous Materials. Bureau of Indian Standard. New Delhi, India. 1978.
[8]. IRC 94. Specification for Dense Bituminous Macadam. Indian Road Congress. New Delhi, India. 1986.
[9]. Ministry Of Road Transport and Highway, 5th revision (2001).