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Parametric analysis on usage of Crumb rubber & Waste plastic on to the assessment of improvements leading to production of modified bituminous mix

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Abstract: Plastics are user friendly but not eco-friendly as they are non-biodegradable. Generally, it isdisposed by way of land filling or incineration of materials which are hazardous. The better binding propertyof plastics in its molten state has helped in finding out a method of safe disposal of waste plastics, by usingthem in road laying.Modified Bitumen is one of the important construction materials for flexible pavements. Use of plastic wasteand Crumb Rubber i.e. the rubber obtained from the waste tyres of vehicles, in the construction offlexible pavement is gaining importance. It is also worth mentioning that, the modifier raw-material has beensourced from disposed waste plastic and crumb rubber. This not only allows us to collect modifier raw-material at low cost, but also provides a solution towards ecological menace posed by increased use ofplastics (non-biodegradable).In the present study, an attempt has been made to use waste plastic andCrumb Rubber. Marshal method ofbituminous mix design was carried out for varying percentages of waste plastic and Crumb Rubber to determine thedifferent mix design characteristics.

Keyword: low density polyethylene, crumb rubber, Marshall Stability, flexible pavements

1. Introduction

In India, it is estimated that over 33 lakh kilometres of road exists. The road transport carries close to90% of passenger traffic and 70% of freight transport. Investigations in India and countries abroad haverevealed that properties of bitumen and bituminous mixes can be improved to meet requirements ofpavement with the incorporation of certain additives or blend of additives. These additives are called“Bitumen Modifiers” and the bitumen premixed with these modifiers is known as modified bitumen.Modified bitumen is expected to give higher life of surfacing (up to 100%) depending upon degree ofmodification and type of additives and modification process used. Different types of modifiers used are Polymers and Crumb Rubber. The consumption of plastics has increased from 4000 tons/annum (1990) to 4 million tons/annum (2001) and it is expected to rise 8 million tons/annum during the year 2009.Nearly 50 to 60% of the total plastics are consumed for packing. Once used plastic materials are thrown out. They do not undergo bio-decomposition. Hence, they are either land filled or incinerated. Both are not eco-friendly processes as they pollute the land and the air. Waste tyres in India are categorized as solid waste or hazardous waste. It is estimated that about 60% of waste tyres are disposed via unknown routes in the urban as well as rural areas. The hazards of waste tyres include- air pollution associated with open burning of tyres (particulates, odour, visual impacts,and other harmful contaminants such as polycyclic aromatic hydrocarbon, dioxin, furans and oxides of

2. literature Review

Bangalore Process (2002), study regarding plastic roads presented. A 25km plastic road was laid inBangalore. The plastic road showed superior smoothness, uniformity and less rutting as compared to aplastics-free road laid at the same time, which began developing "crocodile cracks" soon after. The processwas also approved in 2003 by the CRRI (Central Road Research Institute Delhi). Road life improves throughimproved tackiness and viscosity of the bituminous mix, thereby binding the stones more firmly together and improving the water-resistance of the mix to rain etc.

Justo et al (2002), at the Centre for Transportation Engineering of Bangalore University on the possibleuse of the processed plastic bags as an additive in bituminous concrete mixes. The properties of the modifiedbitumen were compared with ordinary bitumen. It was observed that the penetration and ductility values ofthe modified bitumen decreased with the increase in proportion of the plastic additive, up to 12 % by weight. Therefore, the life of the pavement surfacing course using the modified bitumen is also expected to increase substantially in comparison to the use of ordinary bitumen.

Mohammad T. Awwad et al (2007), polyethylene as one sort of polymers is used to investigate thepotential prospects to enhance asphalt mixture properties. The objectives also include determining the besttype of polyethylene to be used and its proportion. Two types of polyethylene were added to coat theaggregate High-Density Polyethylene (HDPE) and Low-Density Polyethylene (LDPE). The results indicatedthat grinded HDPE polyethylene modifier provides better engineering properties. The recommended proportion of the modifier is 12% by the weight of bitumen content. It is found to increase the stability, reduce the density and slightly increase the air voids and the voids of mineral aggregate.

Shankar et al (2009), crumb rubber modified bitumen (CRMB 55) was blended at specified temperatures.Marshall's mix design was carried out by changing the modified bitumen content at constant optimum rubbercontent and subsequent tests have been performed to determine the different mix design characteristics andfor conventional bitumen (60/70) also. This has resulted in much improved characteristics when compared with straight run bitumen and that too at reduced optimum modified binder content (5.67%).

3. Objectives:

Basic intention is to efficiently utilize the waste plastic in constructive way so that it can be beneficial to society however main objectives of paper are:

- To utilize waste material as a pavement ingredient
- To check the sustainability of waste material in asphalt mixture
- To check the properties of bituminous mix specimen
- To coat the aggregates with the waste plastic material and rubber.
- To check the properties of bituminous mix specimen due to coating of waste plastic material and rubber and to compare the properties of bituminous mix specimen with the properties of coated aggregate.

Table 1. Test on Aggregate

Properties	Observation Result	MORTH Specification (IS 2386)
Flakiness Index(IS 2386 Part I)	12.05%	Max. 30% combined
Elongation Index (IS 2386 Part I)	14%	
Combined Index	26.05%	
Aggregate Impact Value (IS 2386 Part IV)	22.50%	Max. 30%
Abrasion Value (IS 2386 Part IV)	20.30%	Max. 30%
Specific Gravity	2.6	

Table 2. Test on Bitumen

Properties	Observation Result
Penetration (IS 1203-1978)	86.00
Specific Gravity (IS 1203-1978)	1.00
Ductility (IS 1203-1978	75 Cm
Softening Point (IS 1203-1978)	45 Degree Celsius

Table.3 Material and Specific Gravity and Requirement of bitumen mix

Material		Specific Gravity
BITUMEAN CONCRETE	1100-1200 GM	-
COARSE AGGREGATE	50%	2.6
FINE AGGREGATE	30%	2.49
STONE DUST	9.5% - 16%	2.43
Bitumen	3.5% - 5%	0.99
Plastic	2 % - 6%	0.97
Rubber	2% - 6 %	0.96

Minimum stability (Kg at 60^0C)	900
Minimum flow(mm)	2
Compaction level (Number of blows)	75 Blows on each of the two faces of the specimen
percentage of air voids	3-5
Percentage of voids fill	75 - 85

4. Analysis and Results

The BC was prepared by Marshall method using the 80/90 grade bitumen and the various mix design characteristics of the Marshal stability value, Flow value, Bulk Density, Air Voids (Vv), Voids in mineral aggregate (VMA), Voids filled with bitumen(VFB) were found out. The results are shown in table 4.The results show that with 4.5% bitumen content higher value of Marshall Stability value and greaterdensity was achieved. All other parameters were also well within the specifications of MORT&H. Hencewith 4.5% bitumen content of 80/90 gradebitumen varying percentages of LDPE and Crumb Rubber wasadded and BC mix was prepared

Table 4. Marshall Parameters for normal mix specimen

Bitumen (%)	Stability (KG)	Flow (mm)	V.M.A	V.v (%)	V.F.B (%)
3.5	1255	3.35	22.35	4.23	81.03
4	1410	3.4	25.04	4.04	83.85
4.5	1725	3.5	25.45	4.99	80.36
5	1630	4	25.45	5.18	79.63

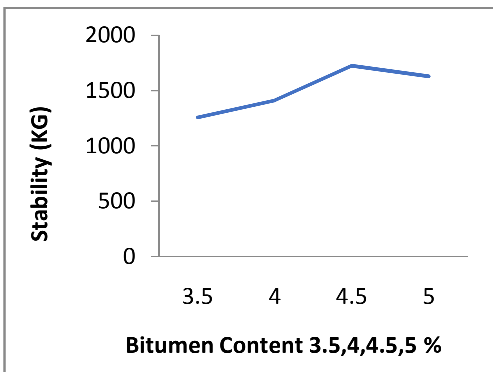


Fig.1 Variation of stability with Bitumen Content

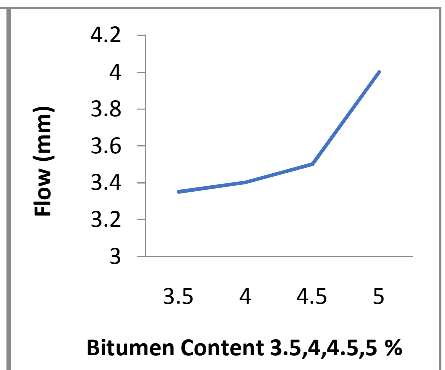


Fig.2 Variation of Flow with Bitumen Content

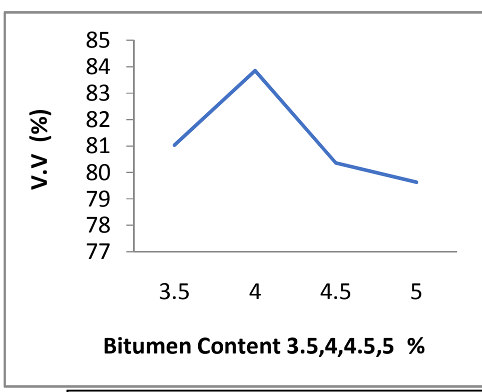


Fig.3 Variation of V.V with Bitumen Content

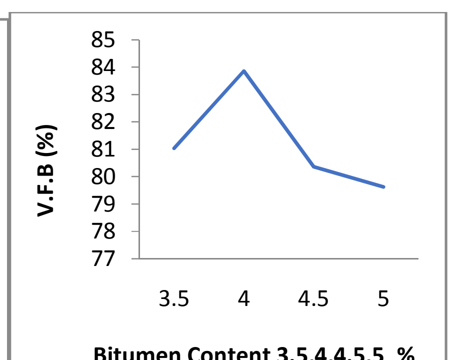


Fig.4 Variation of V.F.B with Bitumen Content

The results of BC mix with varying percentage of LDPE are shownin the following table:

Table 5 Marshall Parameters for Plastic (I) mix specimen

Bitumen (%)	Plastic(%)	Stability(KG)	Flow(mm)	V.M.A	V.V (%)	V.F.B (%)
4%	2	2369	2.30	24.86	4.71	80.8
	4	2456	3.45	25.67	5.12	80.03
	6	2230	3.60	24.97	4.24	82.99

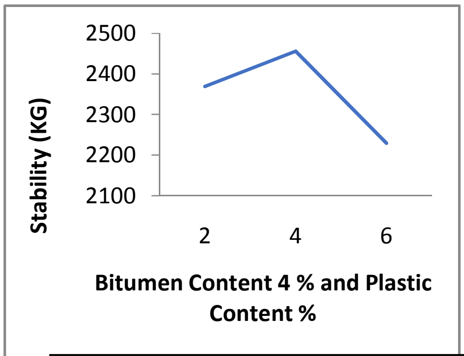


Fig.5 Variation of stability with Bitumen Content (Plastic Modified)

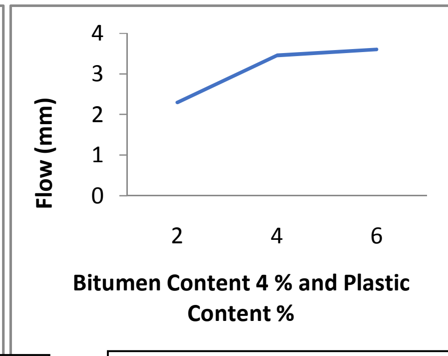


Fig.6 Variation of flow with Bitumen Content (Plastic Modified)

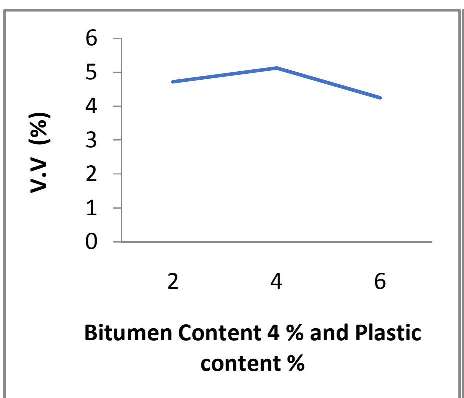


Fig.7 Variation of V.V with Bitumen Content

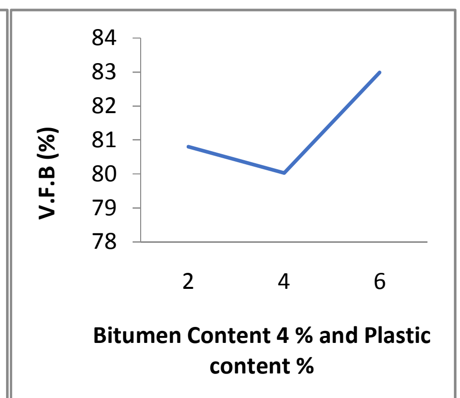


Fig.8 Variation of V.F.B with Bitumen Content

Table 6. Marshall Parameters for Plastic (II) mix specimen

Bitumen(%)	Plastic(%)	Stability(KG)	Flow(mm)	V.M.A	V.v (%)	V.F.B (%)
4.5%	2	2795	2.2	25.57	5.17	79.76
	4	2381	3.0	24.64	4.01	83.72
	6	3105	3.4	26.08	5.86	77.53

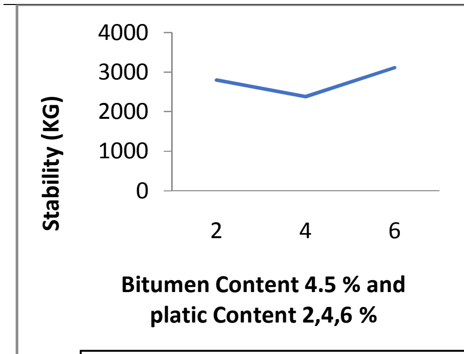


Fig.9 Variation of Stability with Bitumen Content (Plastic Modified)

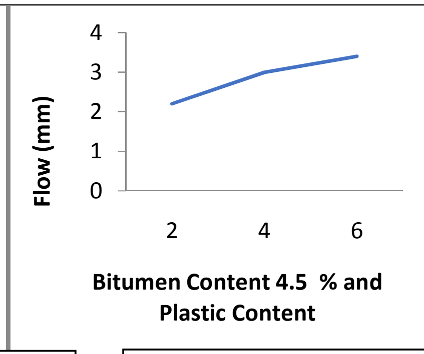


Fig.10 Variation of flow with Bitumen Content (Plastic

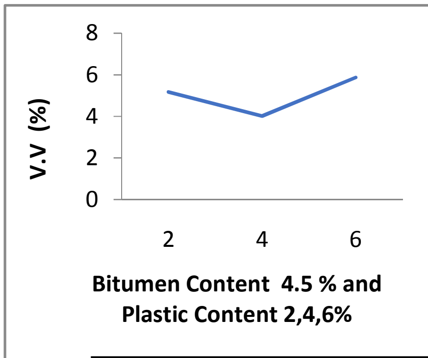


Fig.11 Variation of V.V with Bitumen Content (Plastic) Modified)

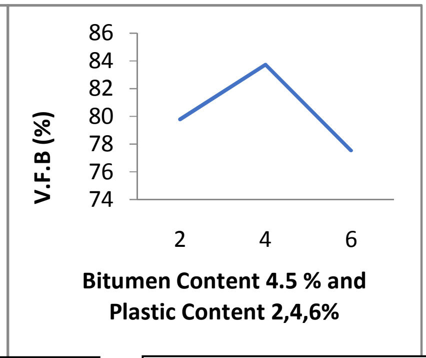


Fig.12 Variation of V.F.B with Bitumen Content (Plastic Modified)

Table 7. Marshall Parameters for Plastic (III) mix specimen

Bitumen (%)	Plastic (%)	Stability(KG)	Flow(mm)	V.M.A	V.v (%)	V.F.B (%)
5%	2	1901	3	25.21	4.89	80.57
	4	2870	3.10	24.95	4.59	81.59
	6	2497	4	25.56	5.37	78.95

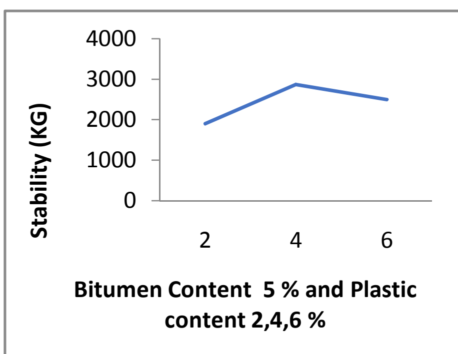


Fig.13 Variation of Stability with Bitumen Content (Plastic Modified)

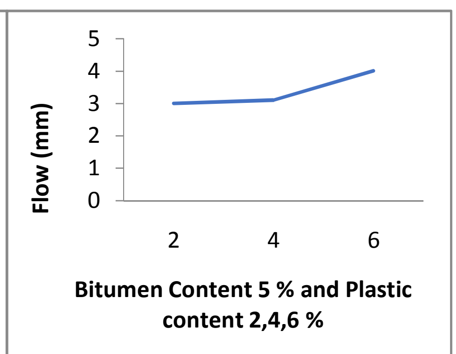
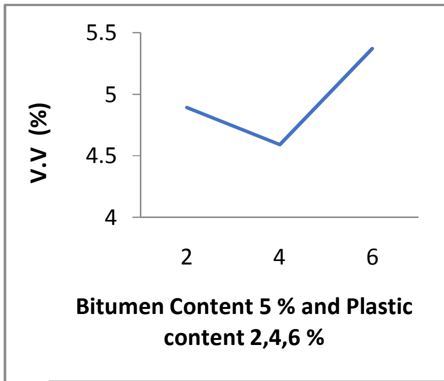


Fig.14 Variation of Flow with Bitumen Content (Plastic Modified)



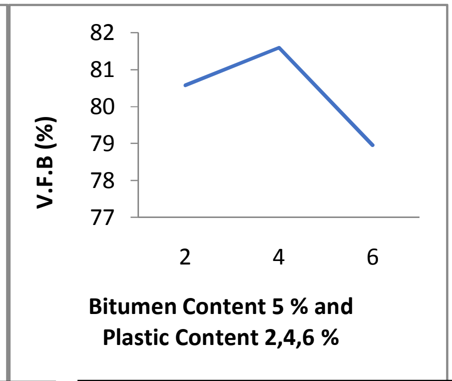


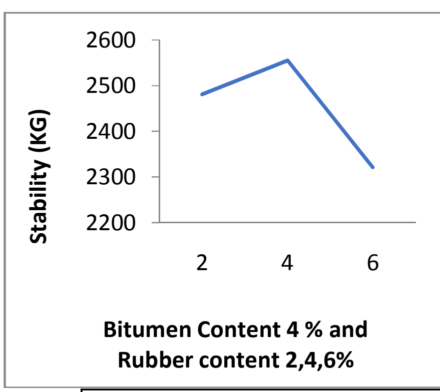
Fig. 15 Variation of S V.V with Bitumen Content (Plastic Modified)

Fig.16 Variation of V.F.B with Bitumen Content (Plastic Modified

From the above results, it is observed that Marshall Stability Values increased with thepercentage increase in the modifier waste plastic i.e. Hence by addition of waste the strength characteristic of themix was enhanced vis- a- vis when it was not mixed with 80/90 grade bitumen.Table 5,6,7shows the results of BC Mix for Varying Percentages of waste plastic. The waste plastic was added to 80/90 grade bitumen in varying percentage of 2%, 4% and 6%. The BC mix was preparedwith varying percentages of bitumen i.e. 4%, 4.5%, 5 % bitumen and the varying percentages of waste plastic as listed above. It was observed that optimum value of bitumen should be 4.5% with added modifications in terms of waste plastic to get a mix with the highest amount of stability.

Table 8. Marshall Parameters for Rubber mix specimen

Bitumen (%)	Rubber (%)	Stability(KG)	Flow(mm)	V.M.A	V.v (%)	V.F.B (%)
4%	2	2481	2.75	25.2	5.2	79.35
	4	2555	3.20	25.01	4.28	82.85
	6	2321	3.80	25.3	4.66	81.55



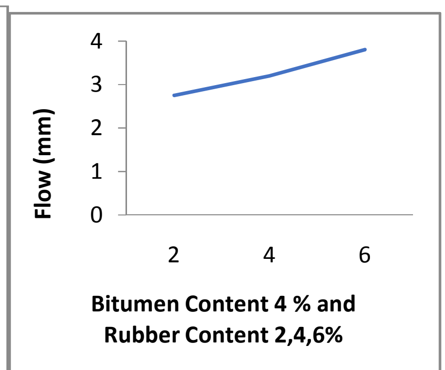


Fig.17 Variation of Stability with Bitumen Content (Rubber Modified)

Fig.18 Variation of Flow with Bitumen Content (Rubber Modified)

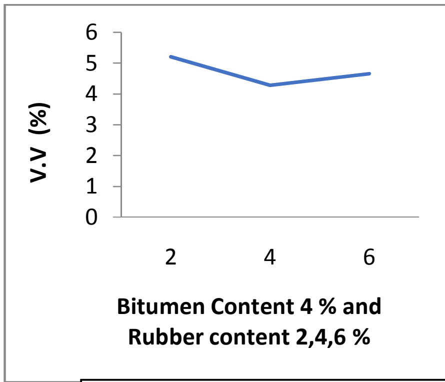


Fig.19 Variation of V.V with Bitumen

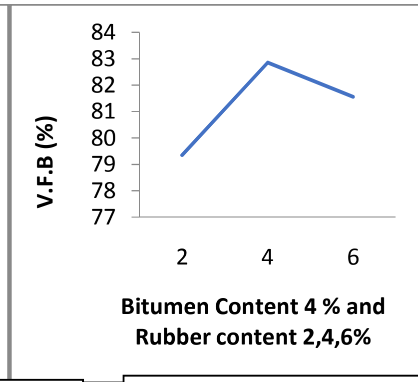


Fig.20 Variation of V.F.B with Bitumen Content (Rubber Modified)

From the above results, it is observed that Marshall Stability Values increased with thepercentage increase in the crumb rubber i.e. Hence by addition of waste the strength characteristic of themix was enhanced vis- a- vis when it was not mixed with 80/90 grade bitumen.Table 8 shows the results of BC Mix for Varying Percentages of waste plastic. The crumb rubber was added to 80/90 grade bitumen in varying percentage of 2%, 4% and 6%. The BC mix was preparedwith varying percentages of bitumen i.e. 4% bitumen and the varying percentages of crumb rubber as listed above.

5. CONCLUSION

The study on the use of waste plastic and Crumb rubber reveals that the Marshal Stability value, which is the strength parameter of BC has shown increasing trend and the maximum values have increased by addition of waste plastic and Crumb rubber. The density of the mix has also increased in both the cases of waste plastic and Crumb rubber when compared with 80/90 grade bitumen. This will provide more stable and durable mix for the flexible pavements. The serviceability and resistance to moisture will also be better when compared to the conventional method of construction. The values of other parameters i.e. Vv, VMA and VFB in both the cases waste plastic and Crumb rubber have found out to be within required specifications. This study not only constructively utilizes the waste plastic and tyres in road construction industry but it has also effectively enhanced the important parameters which will ultimately have better and long living roads. Plastic roads would be a boon for India's hot and extremely humid climate, where temperatures frequently cross 50°C and torrential rains create havoc, leaving most of the roads with heavy distresses. This adversely affects the life of the pavements. The plastic modified bitumen shows better properties for road construction and plastics waste which otherwise are considered to be a pollution menace. It can find its use in this process and this can help in solving the problem of pollution because most of the plastic waste is polymers. In the modified process plastics-waste is coated over aggregate. This helps to have better binding of bitumen with the plastic-waste coated aggregate due to increased bonding and increased area of contact between polymer and bitumen. The polymer coating also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. The road can withstand heavy traffic and show better service life. This study will have a positive impact on the environment as it will reduce the volume of plastic waste to be disposed of by incineration and land filling. It will not only add value to plastic waste but will develop a technology, which is eco-friendly.

6. References

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