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Pavement Evaluation Studies on Low Volume Roads Using Plastic Coated Aggregate and Bituminous Mix

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Abstract

The present study is to carry out the performance evaluation and impact of using plastic coated aggregate (PCA) in bituminous mix in Low Volume Roads, the study reveals that the use of PCA in the roads leads to increase in marshal stability by almost 2% of bituminous mixes. On the other hand reduction of bitumen is also clearly indicated by 8% of its weight. In this study real time field evaluation of modified bitumen aggregate pavement on different roads are carried out to check its various properties and performance. The study indicated that by using waste plastic in roads better strength, Durability, and delayed deterioration is shown. In addition of this eco-friendly disposal of waste plastic can also be done in a constructive manner.

Keyword: Plastic Coated Aggregate (PCA), Low Volume Road, Texture Depth, Roughness, Waste Plastic

1. INTRODUCTION

Plastic can be defined as any synthetic or semi synthetic organic polymer. Mainly there are two types of plastics thermoplastic and thermoset, thermosetting polymers, also known as thermosets, solidify into a permanent shape. They are amorphous and considered to have infinite molecular weight. Thermoplastics, on the other hand, can be heated and remolded over and over again. Some thermoplastics are amorphous, while some have a partially crystalline structure; most of the industrial plastic is made

up of petrochemical. In today's scenario, plastic is everywhere. It is used in packaging, building construction, automobile, agriculture, electronics appliances we can also say that every important sector of the economy have been virtually boosted by the use of plastic.

In India there is a great importance of recycling plastic waste particularly for the reduction in pollution in the environment conceived by dumping. Plastic waste is the major contributor of municipal solid waste. The use of plastic in our country would likely to reach 15 million in which half of the figure is used for packing. India generates 5.6 million metric tons of plastic waste annually, with Delhi generating the most of at municipality at 689.5 metric tons every day, according to a report from the Central Pollution Control Board (CPCB) In India, not so much attention is given on recycling, and as a result the waste materials are usually dumped in landfills which creates serious environmental problem and will also the effect the health. If the plastic waste is properly managed in road construction it will helps a lot to reduce the pollution and disposal problem. The bulk use of plastic waste in our country in road construction especially in low volume roads is possible and we can save lots of virgin materials, as that materials are shortening and its cost of extracting is also more.

Low volume road (LVR) are mainly rural roads, sometimes referred to as village road in India, with daily traffic of less than 450 commercial vehicles per day(CVPD), according to Indian road congress specification IRC:SP:72:2007. Low volume road has its own significance as out of India's total road network (4.69 million km) village and other district road (LVRs) account for an 80% share (MoRTH 2011). The construction maintenance and rehabilitation of LVRs in the U.S. is a major task and involves about 54 % of the country's total annual investigation in transportation system (practico et al. 2011). Due to low volume of traffic LVRs did not attract so much attention during design and construction, which leads to maintenance and poor performance, whereas the government is investigating a lot on low volume roads through the pradhan mantra gram sadakyojna, in which maintenance of 50,000 km of existing rural roads is to be done through 47,000 crore (PMSGY 2012). As say that ″every that sustain us – grown, mined or drilled begins (its journey to us) on a low volume road″ could there may be a more profound statement about prosaic a thing as a road.

The present study emphasizes on the performance analysis of low volume roads as these roads can carry low volume of traffic we can easily mix plastic waste along with other waste materials like fly ash, construction and demolition waste, agricultural waste, etc. if possible, we can also think about the road which are made up of total waste materials, so it will be beneficial in both (a) cost point of view (b) solving environmental problems. The state agencies are also trying to use waste plastic in to the road constructions many road have been laid down by using plastic waste, but now we need more waste materials used not only on pavement but also in sub base, soil stabilization, soil reinforcement so that we can fully utilize the waste materials deposited around us in an eco friendly manner, and also helps to lower down the overall cost of the road.

2. SCOPE AND OBJECTIVE OF THE STUDY

The scope of the study is to assess the performance of plastic tar flexible pavement through various laboratory studies are carried out to determine the optimum binder content for bitumen mixes of different types such as Bituminous concrete(BC) and Dense Bituminous macadam(DBM). After the construction, pavement performance were examined through various tests at different road sections using modified bituminous mix having aggregate coated with plastic waste and ordinary bituminous mix, with the consideration of uniform conditions and compared by result. Some of the low volume roads are chosen as follows:-

- Gormiudotgarh to baloopura, District- bhind (M.P.)
- Mau marg to madanpura, District- bhind (M.P.)
- Gohadchuraha to silonha, District- bhind (M.P.)

The objective of the study is to examine the performance of the road constructed using plastic waste. To evaluate this following specific task are given below;

To measure

- The field density of the road.
- The macro texture of the pavement for the geometrical deposition.
- Gradation of the laid road.
- To evaluate various conditions of the road (rutting, raveling, cracks, potholes, etc.)
- To perform various test on the existing bitumen.

3. METHODOLOGY

There are two processes i.e. wet and dry by which waste plastic is added to modify the bituminous mix. In the wet process, plastic less than 60 micron or below slowly can be mixed with bitumen at 160^0C to 170^0C which is its melting point, mix was stirred for about 30 minute with keeping constant temperature and after that polymer – bitumen mix of various proportion were prepared and lay down on road. Whereas in the dry process aggregate is heated at a temperature of 170^0C - 180^0C and then plastic is added over aggregate which gets coated on it as plastic will melt, the dry process is better in case of blending, as the surface area of aggregate is more and plastic can mix easily over it, we can say that dry process is comparatively better than wet process. In our case the modified mix is prepared through dry process.

3.1 Laboratory studies

- Marshall Test was conducted for both the plastic coated modified mix and ordinary mix aggregate. The material constitute of bituminous mixes are bitumen VG 30, shredded plastic waste, cement. Marshall Stability value is one of the most fundamental studies on the stability of the mix while applying load. The plastic mix is coated over the aggregate mix and then plastic coated mix (PCA) is mixed with the

known quantity of the bitumen and then the material is processed with the conventional procedure of the marshal stability test. The material used in the test are taken considering IS and MoRTH specifications. With the help of the marshal mix block we can find out some more properties of the plastic coated mix like void filled with mineral aggregate, bulk density, specific gravity. Marshal stability is an indicator for the flexible pavement carrying load. The minimum value fixed is 4 KN by IRC with 5 % of bitumen and 95 % of stone aggregate.

In our laboratory studies equivalent percentage of shredded plastic is added into a Binder content to reach optimum binder content. The deviation in marshal stability, Bulk density, void content, flow, and void filled with bitumen with the change in plastic content and binder was then correlated by the optimum binder content.

3.2 Pavement evaluation

Basically there are two main methods of evaluating pavement

(a) Structural evaluation

(b) Functional evaluation

In this study periodic study is carried out two times a year for the above given criteria of performance of the roads. The elementary objective of the pavement assessment is to evaluate as to whether and to what extent the pavement accomplish the expected purpose. So that the strengthening and up keeping job can be done in planned and budgeted time. The present study therefore helps us in finding the structural competence and other technical concern for providing secure and comfortable traffic activity.

Surface distress is a primary and one of the most fundamental indicators of the structural and functional condition of a pavement and is generally give at most priority.

Roughness survey

Road roughness or simply roughness is the term we usually used to describe the relative degree of comfort or discomfort experienced by a road user; pavement must have the uniformity in surface finish within transverse and longitudinal direction. Majorly in all pavement work accomplished, control of surface unevenness is a compulsory requirement. This was measured by the MERLIN instrument whose values are the representation of road quality. The obtained value are converted into the International Roughness Index (IRI) and also with the standards mentioned in IRC SP 16-2004

Table-1: Maximum Permissible values of roughness (mm/km) for Road surface

Type of Surface	Condition of Road Surface		
	Good	**Average**	**Poor**
Surface Dressing	<3500	3500-4500	>4500
Open graded premix concrete	<3000	3000-4000	>4000
Mix seal surfacing	<3000	3000-4000	>4000
Semi Dense Bituminous concrete	<2500	2500-3500	>3500
Bituminous Concrete	<2000	2000-3000	>3000
Cement Concrete	<220	2200-3000	>3000

(Source IRC: SP: 16-2004 Table 3)

Detailed survey were conducted in various sections to measure raveling, potholes, edge break, corrugation, cracks etc.

Texture depth

The capacity of bituminous surfacing to provide the desired skid resistance is basically depended upon the micro structure and macro structure. The macro texture is determined by measuring texture depth which we have done by Sand Patch Test as per BS 598 part 105(1990) on different sections of the pavement. The coarser the texture is the quick the drainage is and less the slipperiness.

Table-2: Permissible texture depth values

Texture depth in mm	Surface characteristics of pavement
0-0.4	Smooth
0.4-0.6	Medium
>0.6	Rough

Field Density: - The compactness of the road can be found out by the field density. The field density is a significant test to find the performance and nature of the road after an extended period of open to the environment. The field density can be reduced by the ageing of bitumen or the crushing of aggregate. Field density can be conducted by the sand replacement method.

4. STUDY AREA

Plastic coated aggregate mix road are being in the light recently and then Pradhan Mantra Gram SadakYojna (PMGSY) a national program under the Ministry of Rural Development, Government of India implemented this idea on the low volume road or village road in all parts of the country. Our study area lies in the Bhind District of Madhya Pradesh where plastic waste is been mixed in road in almost 30 km. We have chosen 3 roads are as follows:-

Site -1

1.	Place	: Gormi Udotgarh to baloopura, District- bhind (M.P.)
2.	Road laying authority	: Pradhan Mantra Gram SadakYojna (PMGSY)
3.	Date of Laying	: 18th September 2013
4.	Plant	: Mini hot mix plant
5.	Source of waste	: municipal waste
6.	Process	: Polymer coated aggregate
7.	Length	: 1.8 km
8.	Road width	: 6.50 to 6.8 m
9.	Carriage way	: 3.75 to 3.80 m

Site – 2

1.	Place	: Mau Marg to Madanpura, District- bhind (M.P.)
2.	Road laying authority	: Pradhan Mantra Gram SadakYojna (PMGSY)
3.	Date of Laying	: 18th April 2014
4.	Plant	: Mini hot mix plant
5.	Source of waste	: municipal waste
6.	Process	: Polymer coated aggregate
7.	Length	: 1.8 km
8.	Road width	: 6.50 to 7.0 m
9.	Carriage way	: 3.75 to 3.80 m

Site – 3

1.	Place	: Gohadchuraha to silonha,District- bhind (M.P.)
2.	Road laying authority	: Pradhan Mantra Gram SadakYojna (PMGSY)
3.	Date of Laying	: 21th March 2014
4.	Plant	: Mini hot mix plant
5.	Source of waste	: municipal waste
6.	Process	: Polymer coated aggregate
7.	Length	: 1.8 km
8.	Road width	: 6.50 to 6.80 m
9.	Carriage way	: 3.50 to 3.80 m

Experimental studies: - The various findings of the laboratory studies are as follows:-

Table-3: Marshal Test Results

Mix		**Bituminous Concrete**	**Dense Bituminous Concrete**
Unit Weight (KN/cu. m)	A	23.33	24.65
	B	23.05	24.15
Optimum binder content (%)	A	4.8	4.3
	B	4.4	4.1
Stripping (%)	A	2	2
	B	0	0
Stability (KN)	A	14.35	19.06
	B	23.65	22.74
Flow (mm)	A	3.55	2.6
	B	3.62	4.04
VFB (%)	A	66.25	74.12
	B	78.03	83.62

Note

A - Mix with ordinary aggregate

B - Mix with plastic coated aggregate (PCA)

5. FIELD STUDIES

The below mentioned roads are low volume road in which various test are conducted on different sections and following results are determined, some part of this road has been laid by using plastic coated aggregate(PCA) and some by ordinary mix. The tests were conducted on both the sections to compare the results, and the performance of the plastic coated roads.

The Survey of the road was undertaken in the three sets in each section and conducted various tests mentioned above; data is summarized as given below:-

Road – 1 Gormi Udotgarh to Baloopura, District- Bhind (M.P.)

Table-4: Pavement Evaluation Data

Tests	**Section with PCA**			**Section with ordinary mix**		
	Data 1	Data 2	Data 3	Data 1	Data 2	Data 3
IRI (mm/km)	4.932	5.213	5.231	5.242	5.423	5.425
Texture Depth(mm)	0.692	0.682	0.708	0.843	0.898	0.847
Field Density(gm/cu.cm)	2.24	2.42	2.45	2.07	2.09	1.96

Road – 2 Mau Marg to Madanpura, District- Bhind (M.P.)

Table- 5: Pavement Evaluation Data

Tests	**Section with PCA**			**Section with ordinary mix**		
	Data 1	Data 2	Data 3	Data 1	Data 2	Data 3
IRI (mm/km)	4.817	5.124	5.314	5.567	5.432	5.327
Texture Depth(mm)	0.602	0.632	0.717	1.852	0.901	0.874
Field Density(gm/cu.cm)	2.25	2.39	2.43	2.03	2.13	1.93

Road – 3 GohadChauraha to Silonha,District- Bhind (M.P.)

Table-6: Pavement Evaluation Data

Tests	**Section with PCA**			**Section with ordinary mix**		
	Data 1	Data 2	Data 3	Data 1	Data 2	Data 3
IRI (mm/km)	4.717	5.387	5.322	5.723	5.432	5.372
Texture Depth(mm)	0.634	0.652	0.673	0.813	0.738	0.896
Field Density(gm/cu.cm)	2.26	2.45	2.38	2.02	2.18	2.03

Fig.1. During Sand Patch test

PROGRESSION OF THE ROUGHNESS

The roughness value of all the roads is quiet high as compared to the standards mentioned above but with the plastic coated aggregate (PCA) road the values are low

as compared to the ordinary mix and on that basis we can understand that roughness is not increasing in case of the PCA, whereas in the case of the ordinary mix the roughness value increases.

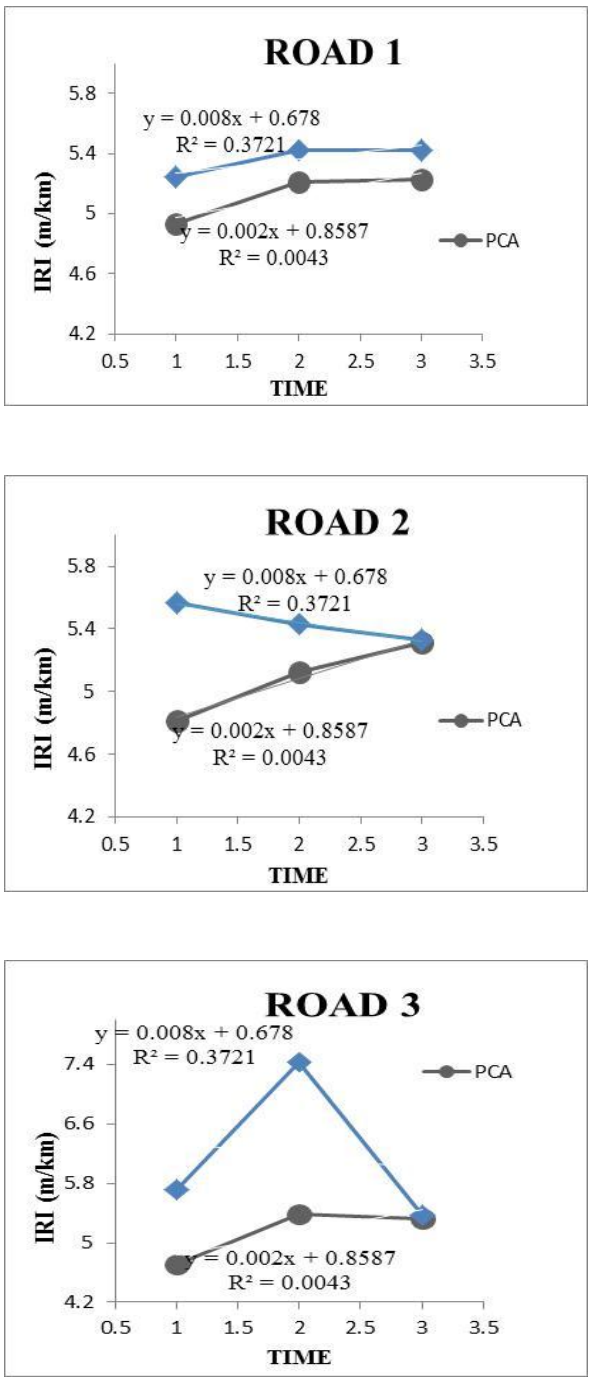


Fig.2. Progression of Roughness

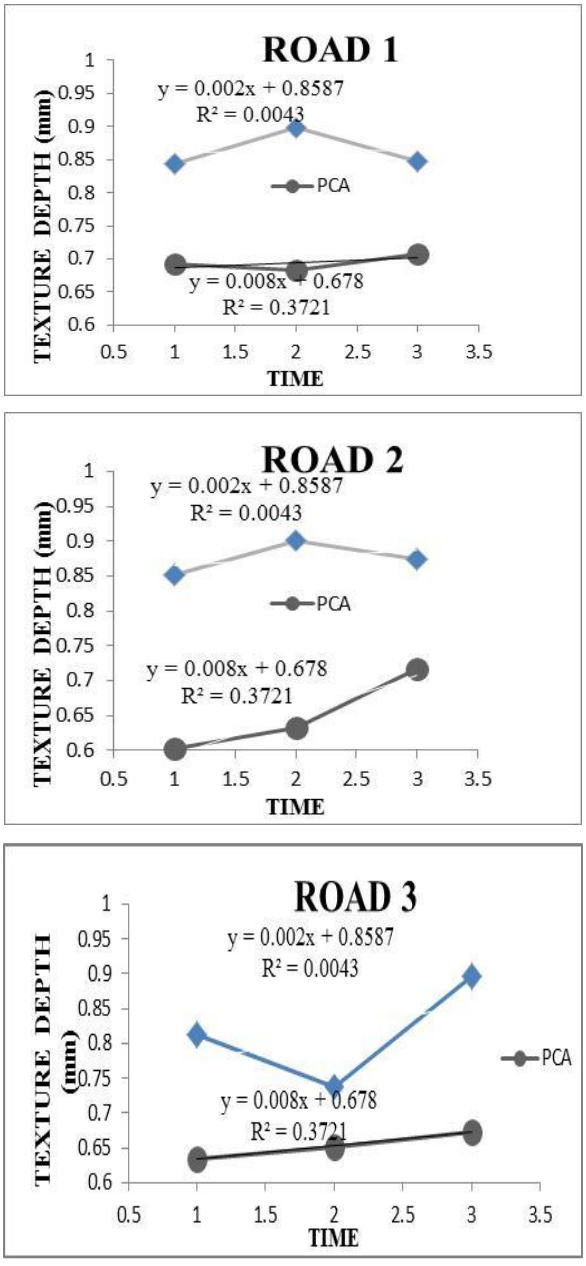
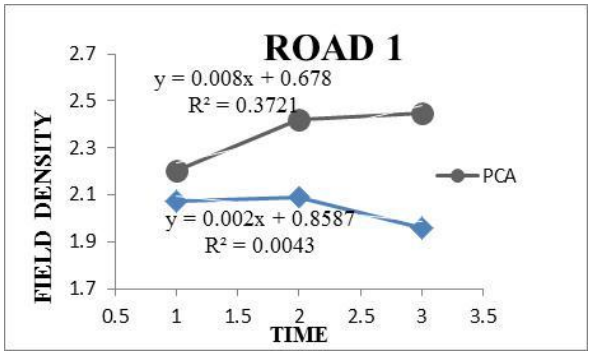
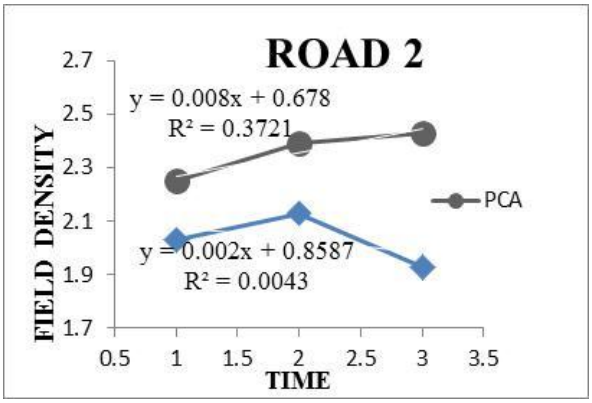


Fig.3. Progression of Texture Depth

Progression of the Texture Depth: - In case of Road 1 and Road 2, the Texture Depth is increasing initially but will come down with the time and it shows that the in PCA roads, the textures is in controlled state but in Road 3 the graph will increase in due course of time and that is may be dependent on specific section or on the construction quality also, But in overall scenario the results of the texture depth is encouraging in the PCA as compare to ordinary mix.





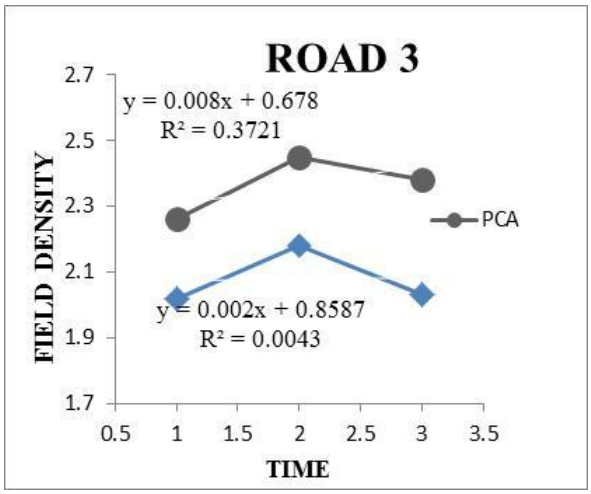


Fig.4 Progression of Field Density

Progression of Field Density- Field Density is a very important parameter of the strength of any road in this progression it is clearly seen that the road 1 and road 2 shows the higher value of field density as compare to ordinary mix. In the road 3 the value of field density is not as high as in the previous one but that in that case only it

is higher than the ordinary mix, the lower value may be due to the quality of construction.

6. RESULTS

As the findings in the laboratory studies tells us that the stability is increased by 1.6 times in Bituminous Concrete(BC) and Dense Bituminous Concrete(DBC) which means that the strength is more in the PCA roads than the ordinary mix pavement. Same as in the case of the optimum binder content which has shown reduction of 4.8 to 4.4 in the Bituminous Concrete and 4.3 to 4.1 in case of Dense Bituminous Concrete so this kind properties show that the structural condition of the road is quiet better in comparison to ordinary mix pavement roads. Voids are also reduced in the case of plastic coated aggregate (PCA) pavement. Waste plastic coated aggregate mix shows Zero Stripping in the case of PCA whereas in the case of ordinary mix pavement it shows the value of 2%. BY performing field performances on differ road section and mixes we came in following findings.

- Huge consumption of waste plastic can be made by this technique and of course than it will be highly beneficial for the environment.
- The whole process can be done in site.
- The value of waste plastic in the recycle market can be increased as the demand is than increased it will give the handsome earning to the rag pickers or self help group.
- The initiation of the distress and the delay of progression are occurred in the plastic coated aggregate. The potholes also develops later in the case of the PCA when compared by the control mix, the plastic coated aggregate road has a clear indication of the resistance towards water soaking ability, and thereby it's not necessary to provide the anti stripping agent.

7. CONCLUSION

Use of plastic coated aggregate in the road construction not only consumes waste plastic but increases the structural and functional ability of the road. Low volume road which has a tremendous scope of adopting these techniques, as government has invested lots of money but due to lack of quality material and monitoring the structural capacity of the road is highly reduced in this context the use of waste plastic is highly recommendable as the performance is increasing with the disposal of the waste plastic in the eco-friendly way, but as the every new technology needs to be adopted by the general public and the local bodies. The social benefit can also be done by this method as the rag pickers and self help group can make handsome money by selling this waste plastic to the construction sector. In this paper we comes to the conclusion that the pavement evaluation which was done on both plastic coated aggregate and ordinary mix shows us that the structural and functional performance in terms of delayed potholes good surface condition and crack initiation and progression

and surface texture the plastic coated aggregate road pavement is better than the ordinary mix.

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