UTILIZATION OF PLASTIC WASTE IN ROAD CONSTRUCTION AND A CASE STUDY OF VYARA FOR SELECTED STRETCH

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Abstract: Infrastructure reflects development of any country, where roads are the main element of infrastructure. Country's growth highly depends on road. Government gives high priority and allocate huge budget on road sector. In this fast growing world people live in heterogeneous life style, in which plastic has taken inevitable place. Plastic waste has reached near up to 5 billion tone worldwide. At present time plastic ban is not right way to reduce plastic pollution, However the efficient management of disposal and collection of waste is right way. Recent government of India also promotes plastic bituminous mix. India has second highest road network in the world with more than 56lakhs kilo meter road network dated on 31st march 2016. 40% of this large road network is remained to pave, which has option of construction or maintenance with plastic bituminous mix. This is the best way to minimize plastic impact on environment. Plastic road will work durably and efficiently.
In this study High Density Polyethylene (HDPE) has been used, which has been collected from municipal solid waste (MSW) dumping site. Wet process has been employed to make Modified bitumen. Different dosage of HDPE was instilled in to VG30 bitumen. To examine physical property of bitumen Penetration Test, Softening Point Test, Ductility Test and Viscosity Test have been performed. Gradation of aggregate has been done for bituminous concrete layer. To check stability Marshall Method has been used, mould preparation has been done with dry process. To evaluate difference between conventional bituminous mix and plastic bituminous mix stretch of 230m was selected from Vyara town. Pavement condition Survey (PCS) has been carried out to check distress in pavement. Results from the PCS of the study show that plastic bituminous mix has low distresses compare to bituminous mix pavement.

Index Terms - **HDPE, PET, Bituminous mix, Plastic Bituminous mix, Pavement Condition Survey (PCS)**

I.INTRODUCTION

India has second highest road network in the work with near around 5.6million kilometer. Our country has very high road network density compare to developed country such as USA, China, Russia, and Japan. Our country has very messy and long road network. So it is very easy to understand that government has to allocate maximum budget to road construction and its maintenance. Government of India did not allocate enough resources to build or maintain its road network. This has changed since 1995, with major efforts currently underway to modernize the country's road infrastructure. The length of national highways in India has increased from 70,934 km in 2010-11 to 101,011 km in 2015-16.

On other side India generates huge amount of garbage every day. Plastic Waste in different forms is found to be almost 9% to 12% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to poor biodegradability it creates stagnation of water and associated hygiene problems. Plastic pollution is the accumulation of plastic products in the environment that adversely affects wildlife, wildlife habitat and humans. It is clearly visible that plastic has taken inevitable place in human life, it is not advisable to put ban on plastic, effective use of waste can reduce its effect, constructing road with plastic waste is one of its effective way.

II.OBJECTIVES

- To compare physical properties of bitumen and modified bitumen
- To evaluate proportion of plastic for which stability is maximum.
- To explore the performance of pavement made with conventional bituminous mix and plastic bituminous mix.

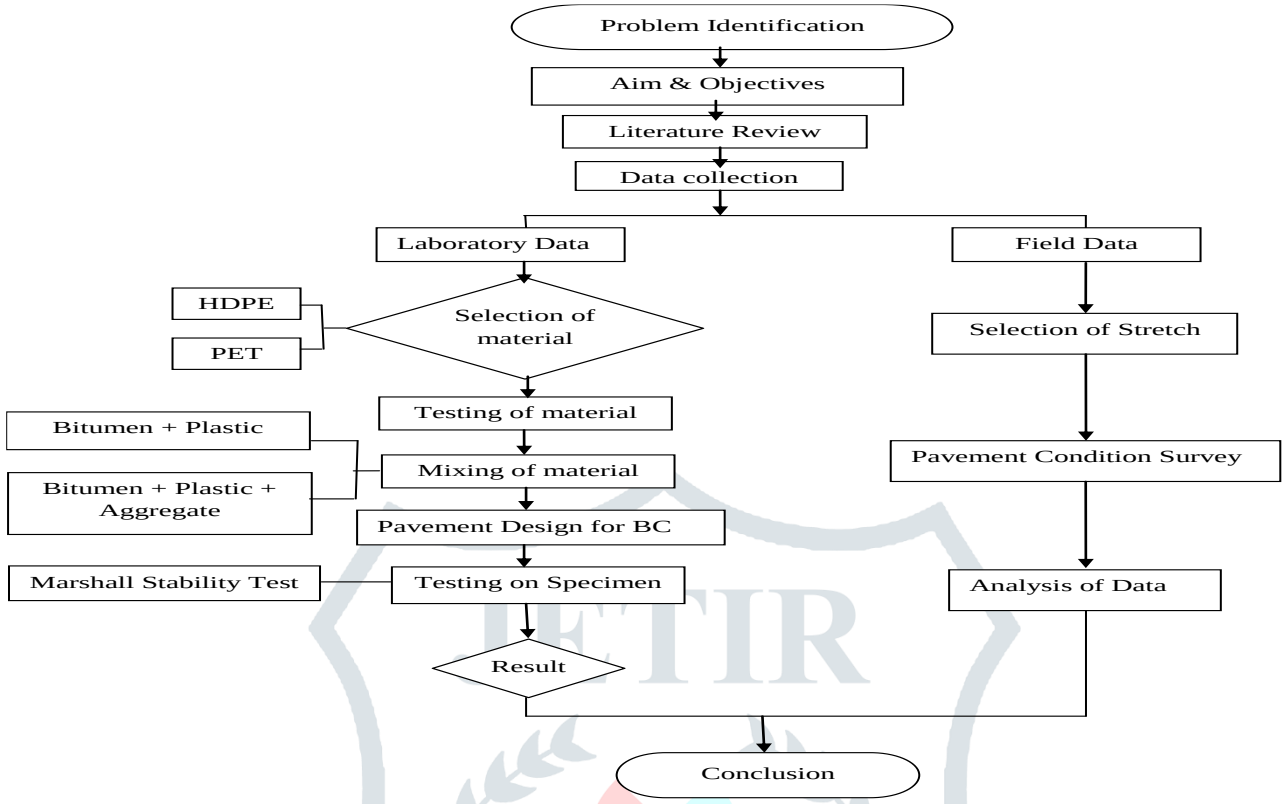
III.LITERATURE REVIEW

Experiments and laboratory testing were done by many researcher for making plastic bituminous road. Two processes are being used Wet process and Dry process. Dry process is developed by Dr. Vasudevan which indicates When the waste plastic, when added to hot aggregate bituminous mix will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength to the road, higher resistance to the water and better performance of the road over a period of time. Another process is wet process which includes waste plastic is directly added in to hot Bitumen. Plastic is mixed with hot bitumen makes homogeneous mix of plastic bituminous mix. This plastic bituminous mix has different physical properties compare to virgin bitumen.

Research was done by S.Rajasekaran, Dr. R. Vasudevan, Dr. Samuvel Paulraj. They mainly used Polyethylene (PE), Polypropylene (PP), and Polystyrene (PS) .These waste plastic material was used because their softening varies between 110℃ – 140℃ and they do not produce any toxic gases during heating but the softened plastics have behavior to form a film like structure over the aggregate, when it is sprayed over the hot aggregate at 160℃. The Plastics Coated Aggregates (PCA) is a better raw material for the construction of flexible pavement. Test of aggregates are performed for PCA as well as PCA-Bituminous mix to derive characteristics. PCA was then mixed with hot bitumen of different types and the mixes were used for road construction. PCA - Bitumen mix showed improved binding property and less wetting property. The sample prepared for the testing showed that

specimen has higher Marshall Stability value in the range of 18-20KN and the load bearing capacity of the road is increased by 100% with utilization of plastic waste.

IV.METHODOLOGY



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4.1SELECTION OF MATERIAL

Globally many types of plastic are available such as LDPE, HDPE, PET, PS, PVC etc. where mostly used plastic is HDPE and PET. HDPE has different application such as bottle caps, chemical resistant pipe, backpacking frames etc. PET is vastly used for making of water bottle. These two plastic are easily available in dumping yard that is why they are selected for research purpose of making plastic bituminous mix.

4.2 PREPARATION OF MODIFIED BITUMEN

For this research VG30 bitumen was modified with plastic such as HDPE and PET. First step is waste plastic has to differentiate as per type then plastic was cut into small pieces. Then grinding of plastic was done to convert plastic pieces in to small particles. Plastic particle passed through 1.18mm micron sieve were taken for mixing with bitumen. For making of modified bitumen 80gm of bitumen was taken and plastic percent by weight of bitumen Starting from 1% - 6% was added in to Bitumen. Wet process was used to prepare modified bitumen. Temperature was kept between 130-150 ℃. Mixing of plastic and bitumen requires time.

4.3 EXPERIMENTAL PROGRAMME

To check change in physical properties of bitumen testing had done over virgin bitumen of VG30. Then testing of modified bitumen had done. For checking physical properties only penetration test, softening point test and ductility test were performed.

Table:1 Test Results of VG30

Bitumen Properties	Bitumen Grade VG30	LIMIT OF RESULTS	Method of test
Absolute Viscosity at 60C, Poises, Min	3150	2400-3600	IS: 1206(Part 2): 1978
Kinematic Viscosity at 135C, cSt, Min	495	350	IS: 1206(Part 3): 1978
Penetration at 25C, 100g, 5s, 0.1mm	49	45	IS: 1203:1978
Softening point,C , Min	52	47	IS: 1205:1978
Ductility at 25C, cm, Min	78	40	IS: 1208:1978

4.3.1 COMPARISON OF PHYSICAL PROPERTY OF MODIFIED BITUMEN

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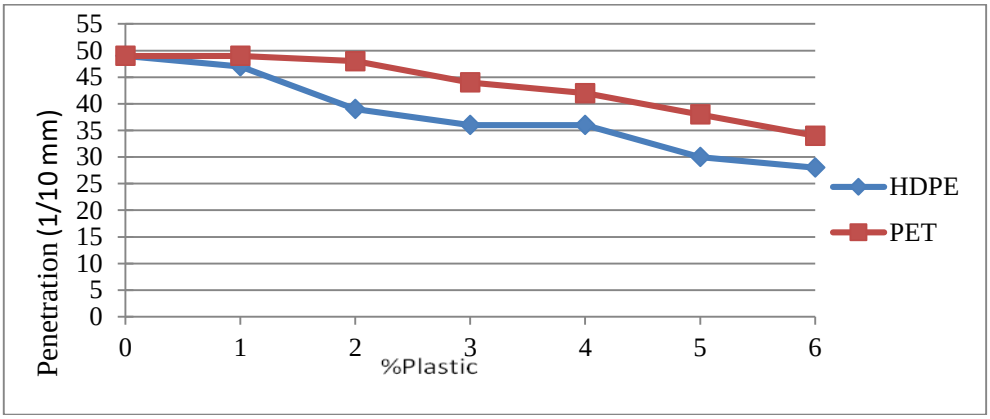


Fig1: Change in penetration value

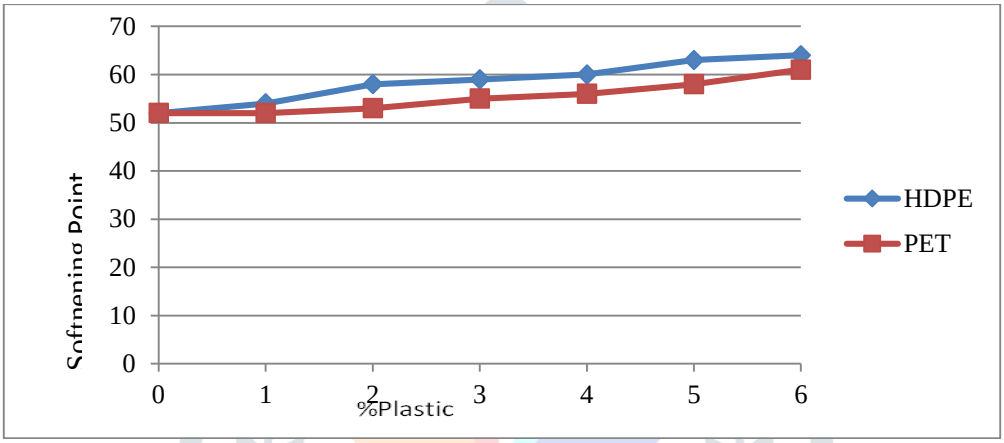


Fig2: Change in softening point

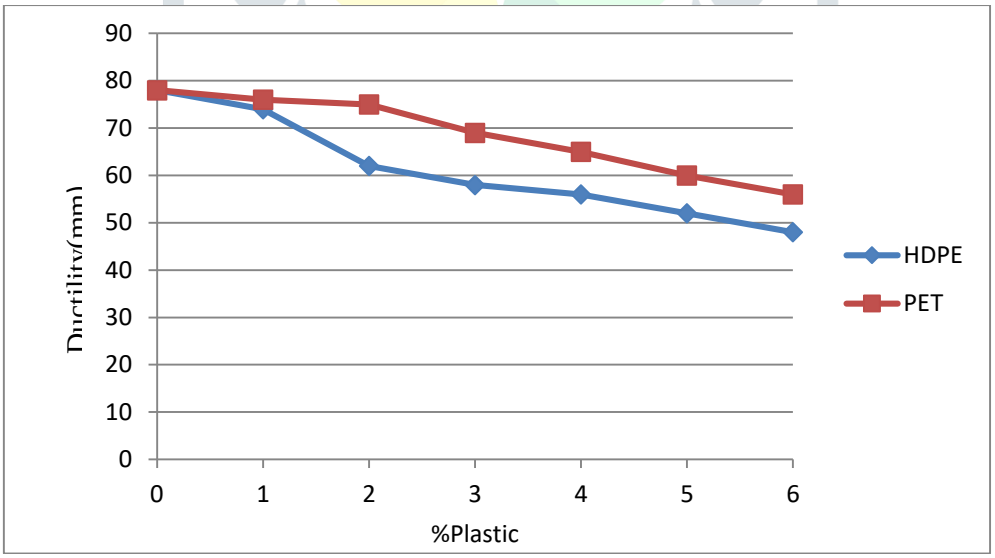


Fig3: Change in ductility value

4.3.2 EXPERIMENTAL PROGRAM FOR CHECKING STRENGTH OF PLASTIC BITUMINOUS MIX.

Aggregate gradation has been done for bituminous concrete mix design as per MoRTH for layer 1. Then Marshall Mould preparation was done for conventional bitumen mix and test was performed. Optimum Binder Content (OBC) was carried out through it and according to OBC, % plastic was added by dry process and Marshall Mould preparation had done.

Table 2: Gradation of aggregate for Bituminous Concrete-1

IS SIEVE mm	Individual Passing				Individual Blending				Cummulative	Gradation Limit		JMF limit	
	HB-1 (26-19) mm	HB-2 (19-13.2) mm	HB-3 (13.2-6) mm	HB-4 6mm down	HB-1 (26-19) mm	HB-2 (19-13.2) mm	HB-3 (13.2-6) mm	HB-4 6mm down		Lower limit	Upper limit	Lower Limit	Upper limit
					13.00%	14.00%	15.00%	58.00%	100.00%				
26.5	100.0	100.0	100.0	100.00	13.0	14.0	15.0	58.0	100.00	100	100	100	100
19.05	38.1	100.0	100.0	100.00	5.0	14.0	15.0	58.0	92.0	90	100	83	100
13.2	18.2	34.6	100.0	100.00	2.4	4.8	15.0	58.0	80.2	59	79	53	85
10	8.3	12.3	45.5	100.00	1.1	1.7	6.8	58.0	67.6	52	72	46	78
4.75	5.9	0.0	19.3	58.53	0.8	0.0	2.9	33.9	37.6	35	55	30	60
2.36	3.1	0.0	8.1	41.62	0.4	0.0	1.2	24.1	25.8	28	44	24	48
1.7	1.5	0.0	3.0	32.62	0.2	0.0	0.4	18.9	19.6	20	34	16	38
0.6	1.1	0.0	0.9	25.63	0.1	0.0	0.1	14.9	15.1	15	27	11	31
0.3	0.6	0.0	0.0	14.35	0.1	0.0	0.0	8.3	8.4	10	20	7	23
0.15	0.4	0.0	0.0	6.97	0.1	0.0	0.0	4.0	4.1	5	13	2	16
0.075	0.2	0.0	0.0	2.35	0.0	0.0	0.0	1.4	1.4	2	8	0.5	9.5

4.3.3. STEPS FOR MARSHALL MIX STABILITY TEST

Step1: Mixing of coarse aggregate, fine aggregate and filler as per design requirement and weight of total mix should be approximately 1200gm.

Step2: Mixing of aggregate with different % bitumen (by weight of total mix)

Step3: Compaction for the mould specimen as per design criteria

Step4: Measurement for diameter and height of prepared mould.

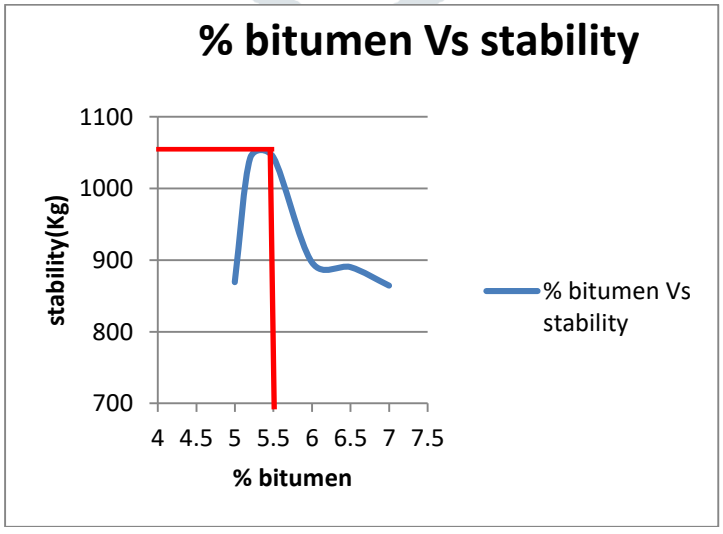
Step5: Weighing of mould in air, in water and SSD weight.

Step6: Check for stability and flow on Marshall mix apparatus.

Step7: Analysis of Result and derive Optimum Binder Content (OBC).

Table 3: Result of Bituminous Mix

Sr No	bitumen %	Gt	Gm	Vv	Vb	VMA	VFB	Stability (kg)	Flow (mm)
1	5	2.29	2.185	4.76	10.10	14.86	67.98	869.40	2.18
2	5.2	2.29	2.207	3.55	10.59	14.14	74.92	950.88	2.68
3	**5.5**	**2.28**	**2.201**	**3.50**	**11.14**	**14.64**	**76.14**	**1043.62**	**3.49**
4	6	2.27	2.189	3.45	12.03	15.48	77.74	897.02	4.58
5	6.5	2.25	2.186	3.07	12.95	16.02	80.83	890.37	5.57
6	7	2.24	2.186	2.50	13.89	16.39	84.75	864.60	6.42



Here, maximum stability was achieved on 5.5% of bitumen. For preparing plastic bituminous mix, % plastic (by weight of bitumen) was added in to mix with reference of 5.5% of bitumen. Increase in plastic % we have to reduce the % bitumen during preparation of Marshall Mould.

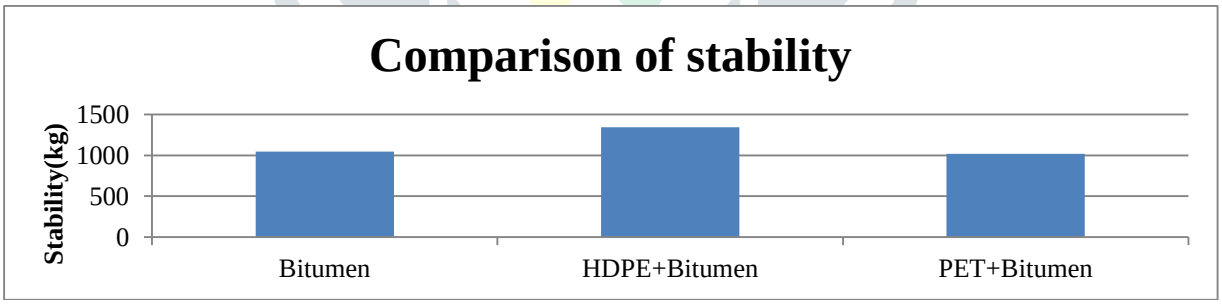
Table 4: Result of Plastic bituminous mix with HDPE

Sr No	% plastic by weight of bitumen	bitumen %	Gm	Vv	Vb	VMA	VFB	Stability (kg)	Flow (mm)
1.0	5.000	5.225	2.207	3.527	10.612	14.139	75.063	771.674	3.297
2.0	5.500	5.198	2.201	3.832	10.527	14.359	73.311	785.585	2.597
3.0	6.000	5.170	2.199	3.924	10.464	14.388	72.728	812.675	2.660
4.0	6.500	5.143	2.185	4.567	10.342	14.909	69.373	892.937	2.573
5.0	7.000	5.115	2.176	5.009	10.243	15.251	67.160	955.987	2.430
6.0	7.500	5.088	2.171	5.261	10.164	15.425	65.891	950.922	2.397
7.0	8.000	5.060	2.158	5.852	10.049	15.900	63.219	1090.127	2.297
8.0	**8.500**	**5.033**	**2.148**	**6.337**	**9.946**	**16.283**	**61.085**	**1340.867**	**2.230**

Table 5: Result of plastic bituminous mix with PET

Sr No	% plastic by weight of bitumen	bitumen %	Gm	Vv	Vb	VMA	VFB	Stability (kg)	Flow (mm)
1	5.000	5.225	2.17	4.83	10.46	15.29	68.42	765.14	3.32
2	5.500	5.1975	2.17	5.15	10.38	15.53	66.84	812.38	2.64
3	6.000	5.17	2.15	5.79	10.26	16.05	63.89	864.58	2.62
4	6.500	5.1425	2.15	5.83	10.20	16.03	63.63	863.65	2.52
5	7.000	5.115	2.15	6.00	10.13	16.14	62.78	934.14	2.35
6	**7.500**	**5.0875**	**2.14**	**6.31**	**10.05**	**16.36**	**61.42**	**1017.87**	**2.22**
7	8.000	5.06	2.14	6.62	9.96	16.59	60.07	930.95	2.13
8	8.500	5.033	2.12	7.16	9.85	17.02	57.89	900.48	2.04

4.3.4 COMPARISON OF STABILITY



Above graph represents that maximum stability was achieved with mix of HDPE and bitumen. However, stability of bituminous mix and bituminous mix with PET is nearly similar.

V. STUDY AREA`

The plastic bituminous road has been constructed between Singhi to Ghata Junction in Vyara during the year 2017 by "Vyara Municipal Corporation". The road comes under the village road. The road has length of 231m, which is trial base road. Just beside this plastic bituminous road; conventional bituminous road has been constructed. There is no any intersection so whatever the vehicles pass through the bituminous road, they has to pass through the plastic bituminous road. Comparison between two pavements can be easily done on this selected stretch. All the conditions for these both pavements are same such as loading, temperature, construction method etc. So this stretch is useful for the study.

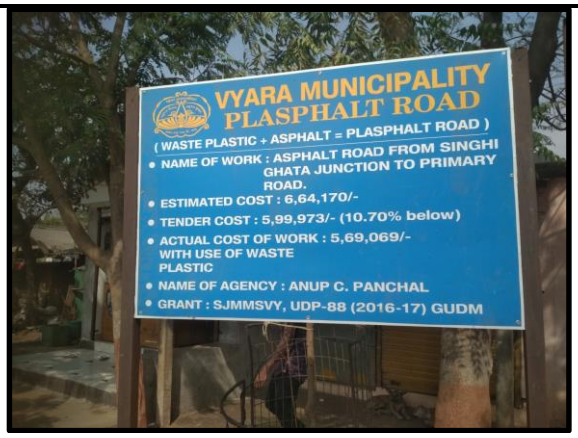
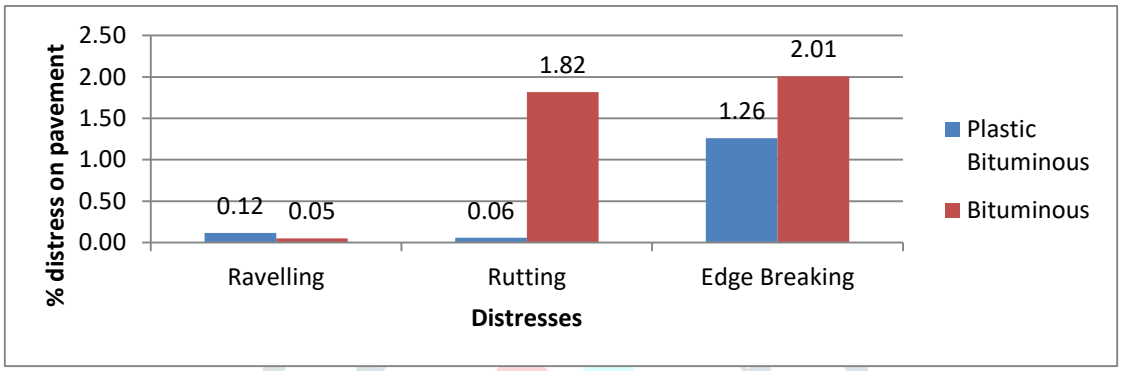


Figure 4: Onsite Board

To check performance of pavement we have to determine the percentage of distress on the both the pavement condition has been carried out as per IRC: 82-2015. It was observed that plastic bituminous pavement has distresses such as Ravelling, rutting, and edge breaking. On other side bituminous pavement has distresses such as rutting and edge breaking.



CONCLUSION

- During laboratory experiment it is clearly observed that addition of plastic emits gas, wet process can not applied in road construction where temperature control is not possible.
- Waste plastic should be properly cleaned, if not done it may have high carbon emission.
- While adding plastic physical properties must change, maximum result influenced by HDPE plastic.
- With increase in plastic percentage penetration value of bitumen decreases ,which means percentage of plastic makes bitumen more stiff, in result softening point of bitumen is increased and ductility of bitumen decreases ,which makes bitumen more brittle.
- As per laboratory result of Marshall Test increase in plastic percent by dry process with bitumen maximum strength obtained at 8.5% and PET gives nearly similar result with comparison of conventional bituminous mix. However, result of plastic bituminous mix does not match with design criteria of Bituminous concrete given in MoRTH 5th revision, Hence more experimental work can be done over it.
- From Pavement condition survey it is concluded that pavement with plastic bituminous mix have less distress compare to conventional bituminous mix. Pavement with plastic bituminous mix has high ravelling percentage, where pavement with conventional bituminous mix has maximum rutting percentage.

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