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Optimal use of Waste Plastic for Construction of Flexible Pavement

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***Abstract*:- Day by Day use of plastic we called carry bags, cups etc. is increasing constantly at a rapid rate. Which, result in enormous accumulation of plastic waste on the earth surface. Almost 50% - 60% of total used plastic are consumed in packing industry. After using plastic material, it becomes non-useable such plastic taken into consideration as plastic waste. This waste plastic is not easy to deteriorate and having long life on the surface without decomposition. Inappropriate practice of discarding waste plastic leads to various health issues, economic loss & deplete environment. The present paper is about tests conducted on different material of Flexible Pavement such as aggregates, bitumen and bituminous mixes. To find out cost effectiveness, quality & performance of pavement and durability.**

Keywords: Partial blending material, dry process of mixing, thermoplastic elastomer

1. INTRODUCTION

In today's day to day lifestyle Plastic is taken fame everywhere. The principal issue concerned with is how to dispose plastic waste generated by use of such huge amount of plastic. This imperishable plastic waste is rising tremendously. Researchers concluded with that the plastic waste can be on earth surface for 4500 years without affecting and deprived of deterioration. This is ultimatum for discarding plastic waste, not figure out by itself. So, for that need certain practical steps started acting from the ground level.

Day by day vehicular traffic on road is increasing which is creating traffic load on roads. By considering day to day arising traffic requirement to rise the load bearing capacities of roads. Plastic can be use in a versatile way. Plastic becomes a inexpensive and productive unprocessed material in various product due to revolution in industrial sector which leads to production of plastic on large scale.

About 5.89 million Km of road infrastructure is posses with India. Initiation from road repairment up to development of new plastic road will help to dispose such huge plastic waste. Construction of plastic road is environment friendly technique, also create employment.

2. LITERATURE REVIEW

Ravi Shankar et al. (2013) concluded that 8% alteration of plastic waste by weight of bitumen will optimized the engineering property of pavement surface [4].

Sharma 2015 in research found that, dry process of bitumen mix performs better comparatively wet process. Approx. 10% of alteration by waste plastic, by weight of bitumen improves the life of pavement & show better drainage and enhance the indirect tensile strength [6].

Dr. Khandekar et al. (2015) studied; it is not new to use plastic waste in construction of FP. Aggregate is the raw material which is mainly responsible for strength of road. He suggested to use well graded aggregate for the preparation of HMA mix [7].

Nemade et al. in 2013 experimented on processed plastic waste mixed by dry process with bituminous concrete. It is found that at a penetration grade of 60/70 modified bitumen performance better. Bitumen is kept at substantial temperature with shredded plastic, further heating it gets adhere to aggregate form a layer over it. Studied about 50 experimental specimens by changing % of shredded plastic waste and bitumen by weight, resulted in to about ten percent replacement of bitumen by plastic waste. This is boom for Indian economy system and for environment too. Life of modified bitumen is more than the conventional one. Raised in stability of pavement occurred. No bleeding & less water absorption were considered as benefits of using plastic in road [8].

In the year 2015, Naktode et al. in his study compare the test results of modified bitumen with the help of plastic waste and polymers. Plastic pavement provide good standard of pavement and durable, also lower the construction cost. While polymer modified bitumen road will raise the construction cost with durable nature of pavement. His study focused on road using plastic and got remarkable results. Ten percent of plastic waste found feasible to replace with bitumen [9].

Bale (2011) introduced three category of polymers thermoplastic elastomers, plastomers, and reactive polymers this classification was depend on how they avoid settlement. He experimented mainly in two ways firstly on bitumen alteration with these different

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types of polymers and secondly with polymer is blended with aggregate. He found that thermoplastic elastomers are best suited polymer for road industry [10].

3. OBJECTIVE OF STUDY

1. To study the engineering behavior of raw material of road & existing index property.
2. Conduction of trail for different proportion of constituent ingredients with plastic.
3. Comparing results of plastic-coated aggregate with normal aggregate and bitumen.
4. Come to an end with finding right % of plastic which can be mixed strength for achieving high compressive strength.
5. For optimum % of plastic test specimen is prepared, for which different engineering and index properties is being tested.
6. Observe the constrain in strength and stability.

4. EXPERIMENTAL RESULTS

Table 4.1: Results of Tests on Aggregates

Sr. No.	Test	Specification	Results	Standards
1	Crushing Value	Pure Aggregate	22%	30% (max)
		Aggregate With Plastic Coating (5%)	17.2%	
2	Impact Value	Pure Aggregate	5%	30% (max)
		Aggregate With Plastic Coating (5%)	4%	
3	Abrasion Value	Pure Aggregate	10%	30% (max)
		Aggregate With Plastic Coating (5%)	7.2%	

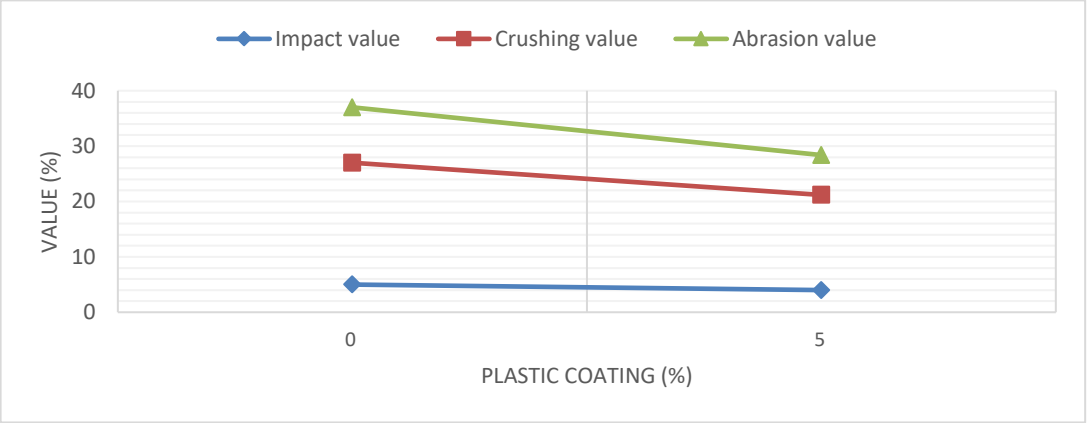

Figure 4.1: Graphical Representation of Tests on Aggregates

Fig. 4.1 shows that the strength of aggregates get increased after coating with plastic which is beneficial in pavement.

5.3 RESULTS OF LABORATORY TESTS ON BITUMEN

The results of various tests conducted on bitumen are as shown in Table 4.2:

Table 4.2: Results of Tests on Bitumen

Sr. No.	Specification	Results						
		Penetration (mm)	Ductility (cm)	Soft. Pt. (^{0}C)	Flash pt. (^{0}C)	Fire pt. (^{0}C)	Viscosity (sec)	Loss on heating (%)
1	Pure bitumen	86	83	45	250	290	292	0.31
2	6% replacement	80	60	48	260	300	182	0.2
3	8% replacement	75	54	56	268	312	168	0.16
4	10% replacement	60	50	62	285	330	154	0.21
5	12% replacement	53	44	69	290	342	135	0.24
6	15% replacement	46	39	74	300	360	121	0.29
	Standard values	60 min	50 min	40 min	220 min	290 Min	50 Min	1% Max

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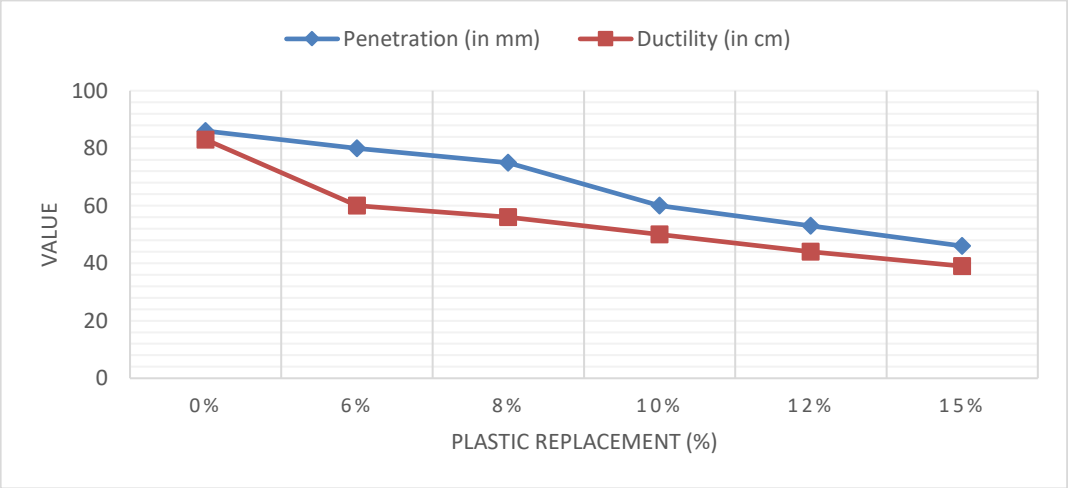

Figure 4.2: Graphical Representation of Penetration and Ductility Tests

Fig. 4.2 shows that after replacement of plastic with bitumen, there is decrease in penetration & ductility value which indicates that the bitumen is getting harder with more plastic replacement.

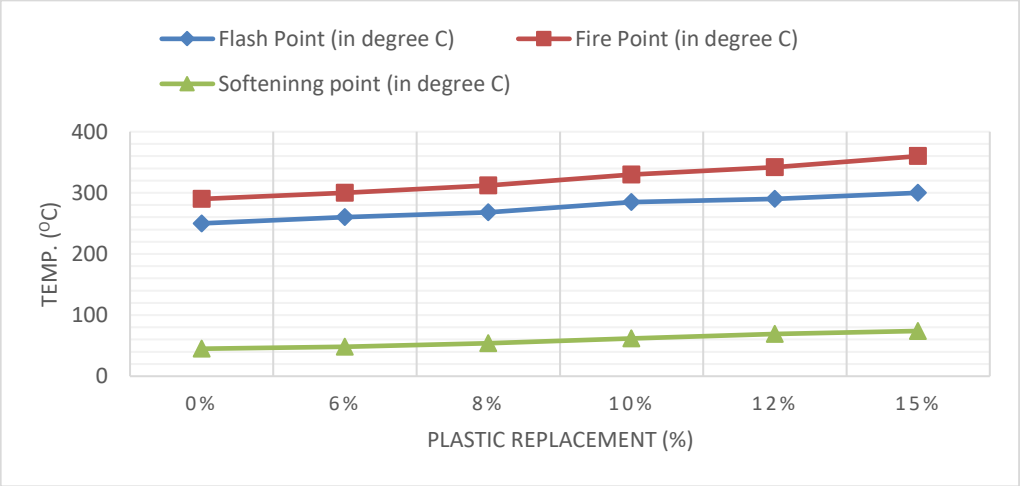

Figure 4.3: Graphical Representation of Flash, Fire and Softening Point Tests

Fig. 4.3 shows that with increase in plastic percentage, there is an increase in flash, fire and softening point which indicates more susceptibility of bitumen in tropical regions.

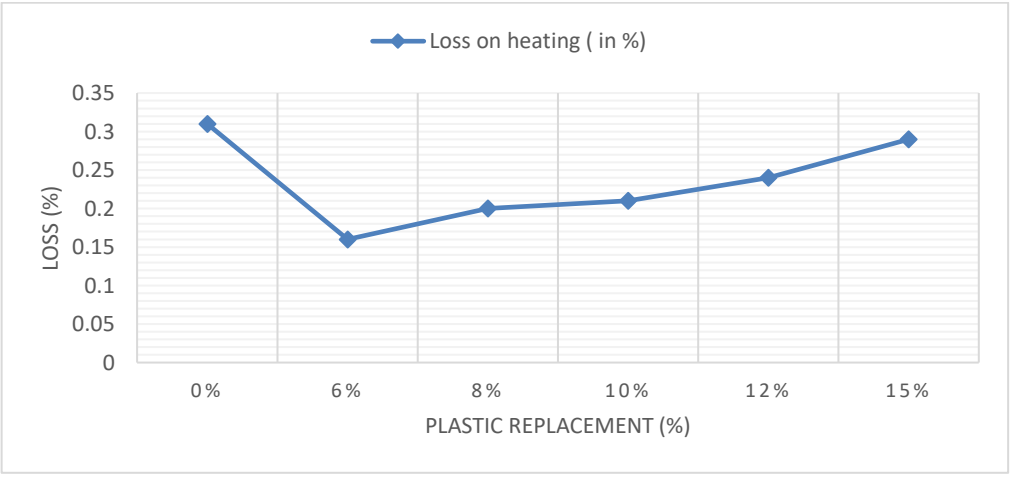

Figure 4.4: Graphical Representation of Loss on Heating Test

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Fig. 4.4 shows that addition of plastic shows slight increase in loss on heating.

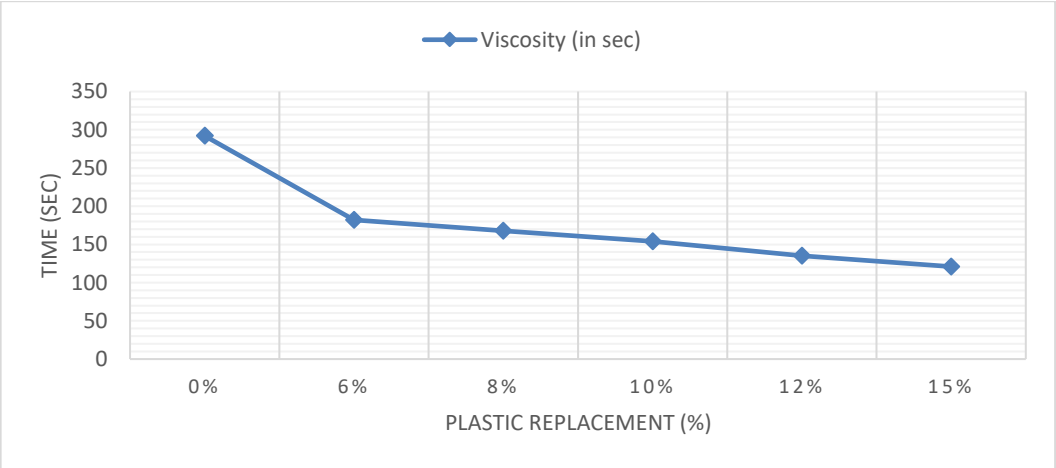

Figure 4.5: Graphical Representation of Viscosity Test

Fig. 4.5 shows that reduction of viscosity is useful to lower the mixing and compaction temperature of asphalt.

RESULTS OF LABORATORY TESTS ON BITUMINOUS MIXES

The observations and calculations for finding out Marshall Stability parameters are as follows:

Table 4.3: Marshall Stability Parameters

Sr. No.	Parameters	Pure Bitumen	10% Replacement	Standard values
1	Theoretical Specific Gravity (Gt)	2.52	2.49	-
2	Bulk Specific Gravity (Gm)	2.381	2.37	-
3	Air Voids (Vv)	5.56%	4.81%	3-6%
4	Voids In Mineral Aggregate (VMA)	18.52%	17.15%	Min 14%
5	Voids Filled with Bitumen (VFB)	69.95%	71.95%	65-75%

From Table 4.3, it is clear that after addition of plastic in bitumen, there are less air voids observed thereby increasing the stability value.

The results of various tests conducted on bituminous mixes are as shown in Table 4.4:

Table 4.4: Result of Tests on Bituminous Mixes

Sr. No.	Test	Specification	Results	Standard values
1	Marshal Stability Test (Stability)	Pure Bitumen	600 kg	Minimum 340 kg
		10% Replacement	980 kg	
2	Marshal Stability Test (flow value)	Pure Bitumen	8.5 mm	Min 8 mm Max 17 mm
		10% Replacement	11 mm	
3	Compressive strength of bitumen	Pure Bitumen	860 kg	Minimum 700 kg
		10% Replacement	1740 kg	
4	Indirect tensile strength of bitumen	Pure Bitumen	370 kg	Minimum 330 kg
		10% Replacement	700 kg	

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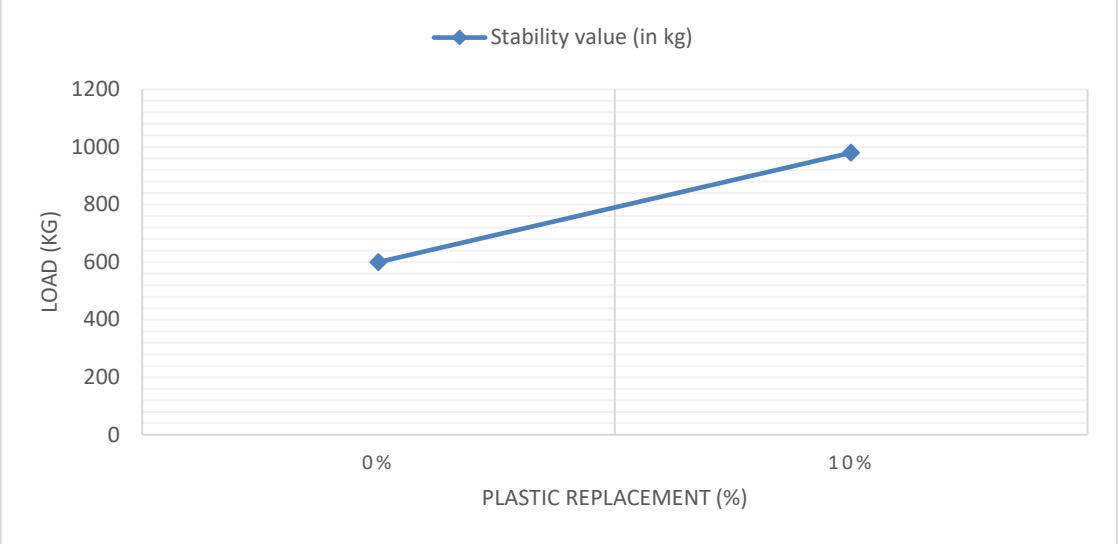

Figure 4.6: Graphical Representation of Marshall Stability Test

Fig. 4.6 shows that addition of plastic shows increase in stability value which is useful to sustain large load.

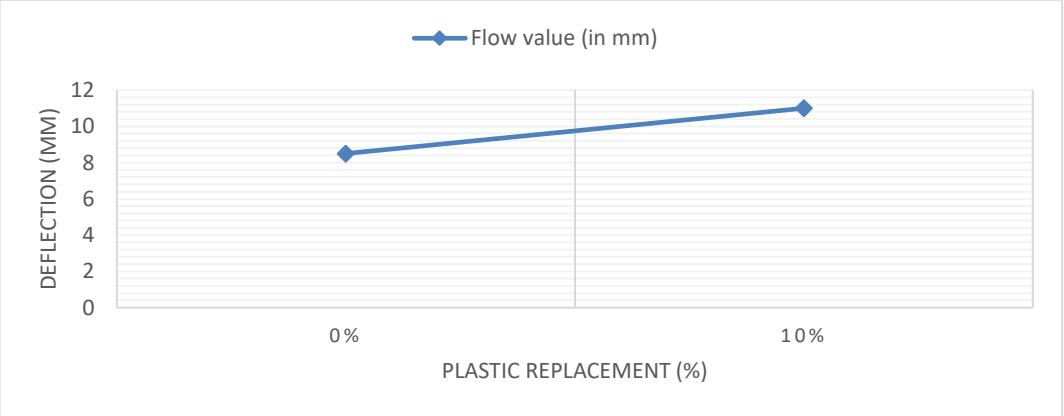

Figure 4.7: Graphical Representation of Marshall Flow Value Test

Fig. 4.7 shows that replacement of plastic shows increase in flow value i.e. less resistance to deformation but change is very little which is in specified limit.

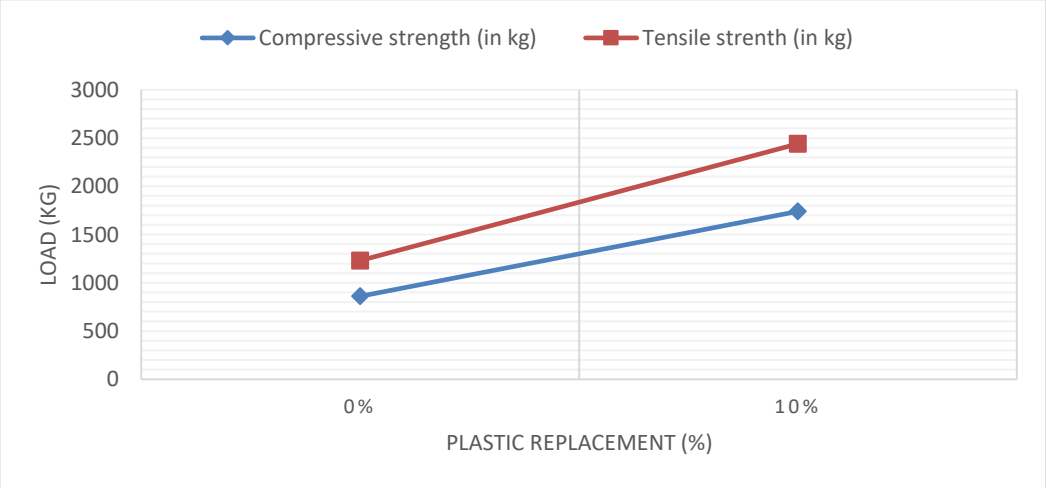

Figure 4.8: Graphical Representation of Compressive and Indirect Tensile Strength Test

Fig. 4.8 shows that addition of plastic shows increase in compressive and tensile strength.

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5. DISCUSSION & RESULTS

By 5% coating of plastic waste to the aggregates, test results shown that there is a better load resisting property than conventional aggregates. Due to 10% replacement of plastic waste in bitumen, there are better results for all the properties such as hardness, consistency, etc. S. N. Nemade (2013) has shown 8% plastic replacement in bitumen. But he had carried out work on VG 20 grade bitumen. Plastic addition in bitumen, makes it harder. Due to such increased hardness, it shows more temperature susceptibility. It requires more temperature for melting as seen by softening point, flash and fire point tests. Due to such higher flash and fire point, these plastic-bitumen samples can be used safely in tropical regions such as North Maharashtra. There was a limitation of burning of plastic in Lab for project work which lead to air pollution. But when it is used in large scale site work, there will be no air pollution. By using these plastic-bitumen samples, the load carrying capacity can be increased by 67% as compared to conventional bituminous mix. The compressive strength gets increased by 100% as compared to conventional bituminous mix. Due to 10% replacement, there is a saving of Rs. 52500 per km road construction as per current market rates. Generally, a normal pavement's quality of road may lasts four to five years, plastic-bitumen paved roads is usually last up to 15 years or more. Maintenance cost of road will reduce because rainwater will not seep through, due to addition of the plastic in the tar. So, this technology will result in lesser road repairs in comparison with normal roadways. Already, 15 km long road laid in Jamshedpur with this method. Government taking constant efforts for such green mix design.

Conclusions draw from experimental study is given below:

- 5% plastic coating samples shown more strength than conventional bitumen.
- Plastic as a 10% replacement in bitumen can be used as an optimum percentage value for bituminous mix design and testing.
- 10% plastic replacement in bitumen shows better results for pavement properties.
- 10% replacement in bitumen reduces the cost by Rs. 52,500 per km road construction.
- It is possible to use plastic as a blender while designing FP. Either partially alter bitumen or layered over aggregate.

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