

UTILIZATION OF WASTE PLASTIC IN FLEXIBLE PAVEMENTS

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Abstract - Plastic are typically organic polymers of high molecular mass and often derived from petro-chemicals and becoming a major problem in causing environmental pollution when it burns. They were widely used because of their ease in manufacturing, low cost, and versatility. Utilization of these waste material like plastic bags, bottles, etc by partial replacement of bitumen in bituminous mixes to improve the properties of mix in addition to solving disposal problems. The waste plastic like bottles, plastic glasses were used are cleaned and cut into pieces of size ranges from 2.36mm to 75 microns and sieved. These pieces were added evenly around the hot aggregates and heated up to 160 °C and heating the bitumen up to 130 °C. The resultant mix was used in the flexible road construction. It also increases the road life and also as well as help in decrease of pollution to the Environment. Plastic roads are very useful in the hot climatic areas. By using of this type of waste plastic in the construction of pavement can increase the strength, durability etc., by which the bituminous pavements are failing. Bituminous mix is a composite material mostly used in construction projects like road surfacing, parking lots etc., It consists of bitumen (used as a binder) and mineral aggregate which are mixed together and laid down in layers then compacted.

Key Words- Waste plastic, Environmental pollution, Partial replacement, Bituminous mix, Bituminous pavements.

1. INTRODUCTION

Plastic is a synthetic material made from a wide range of organic polymers such as polyethylene, PVC, nylon, etc., that can be moulded into shape and then set into a rigid or slightly elastic form. Plastics are durable, cheaper and degrade very slow. The chemical bonds that make plastic to degrade vary slowly and it is a great threat to environment. The municipal solid waste contains mixture of bio- -degradable and non-biodegradable solids. The non-biodegradable solids consists of plastic in the form of bottles, carry bags etc. The waste plastic is used as to make binders stiff which reduces the rutting, thermal cracking, stripping, cost of maintenance of pavement. It improves the fatigue resistance, bituminous pavement durability, reducing cost of laying pavement and reducing the pollution. The majority of waste plastic is polyolefin which includes high density polyethylene (HDPE), linear low density polyethylene (LLDPE), polypropylene (PP) and high molecular weight polyethylene (HMWP). The waste plastic modified bituminous mix gives more service, no potholes, less failure due to rutting, etc., Because of several reasons the polymer modified bitumen mix is used in laying pavements.

Rapid growth of industries, increase in the population, increase in the vehicular traffic, the layers of bituminous roads plays a vital role in facing the heavy loads. So, the bituminous surface layer experiences a great impact of heavy loading. The surface layer should be modified in bringing more service life for pavement. The use of modified bituminous surface layers are important to be implemented. This plastic modified bitumen mix is also economic and doesn't cause any environmental pollution.

This paper gives the proper utilization of waste plastic in bituminous mix to enhance the pavement performance, minimize the bitumen cost by giving more service life and to protect the environment. In this study we are conducting Marshall Stability test to increase slip resistance and resistance against seasonal variations.

1.1. OVERVIEW OF THIS RESEARCH

Several researches have been made to protect the environment in inventing several things and this modified bitumen provides a very long life and economically low cost. Polymer-modified bitumen is the one of the invention in saving the environments and above mentioned factors. This modified bitumen is the alternate to the conventional bitumen concrete which doesn't utilize much bitumen and increases the binding property of bitumen. The elastic nature of plastic stiffens the bond between aggregates and bitumen.

1.2 PAST RESEARCH ON THIS PROJECT

Dr. Rajagopalan Vasudevan, Indian chemistry professor had made a wide research on using the waste plastic and awarded with one of India's highest civilian awards, The "Padma Shri", for his ground-breaking research on re-using the waste plastic in a very unusual way and regarded as "Plastic Man of India".

2. LITERATURE REVIEW

S.NO.	AUTHOR	TITLE	CONCLUSION
1.	Ms. Jamdade P. K., Mr. Patil RaviKiran, Mr .Patil Prathik, Mr. Rajurwar Rohit, Mr. Loya Tushar, Mr.Shaik Amer, Mr. Shaik Alfaiz	Use of waste plastic in flexible pavement road construction	Concluded that the penetration and ductility resistance of modified bitumen sample increases within the range of 0-12% when the plastic of 8.4% is added to conventional bitumen mix and air voids decreases so as increases the percentage of plastic
2.	Sasane Neha. B., Gaikwad. Harish., Dr. J R Patil and Dr. S D Khandekar	Application of waste plastic as an effective construction material in flexible pavement	Concluded that increase of waste plastic in bitumen increases the properties of aggregates and bitumen, the optimum content of plastic used can be done up to 10%
3.	Yash Menaria and Rupal Sankhla	Use of waste plastic in flexible pavements- Green Roads	Discussed about the comparison of various properties of conventional bitumen and polymer-modified bitumen. The test results show the improved properties of polymer-modified bitumen.
4.	Miss Apurva J Charan	Use of plastic waste in flexible pavements	Concluded that the properties of aggregates are improved. Stripping value is reduced to nil and water absorption also reduced to nil.
5.	Plastic roads	Ahmed Trimbakwala	Concluded that the binding property of plastic waste

3. OBJECTIVES

The main research of this research is to utilize the waste plastic in bituminous pavements as it is causing environmental pollution.

The objectives of this research which we have to achieve are

- The optimum use of plastic in bituminous pavements at which it gains maximum strength and durability properties.
- The comparison of conventional bituminous mix and polymer-modified bituminous mix.
- To reduce the plastic disposal problems.

The countries like Netherlands, United Kingdom, Australia Indonesia, etc are also has the plastic-modified roads.

3.1. COLLECTION OF PLASTICS

The plastic is collected from the municipal agencies. This plastic should be having the softening point which is greater than bitumen and its melting points should be between 160°C -170°C is collected. This plastic should be cleaned to remove any organic or waste materials and shredded to the size between 2.36mm to 75 microns. Thus the density of the plastic fiber should be around 0.4-0.5g/cc which is so small when compared to bitumen.

Types of plastic which can be used are:

- PP(polypropylene)
- PET(polyethylene)
- HDPE(high density polyethylene)
- LDPE(low density poly ethylene)
- PS(polystyrene)



Fig.1: Waste Plastic

- PVC (poly vinyl chloride) is not used because its melting point is very high. Because of this reason PVC is not used.

4. METHODOLOGY

The methodology contains step by step procedures of testing of individual materials for the quality analysis, preparation and testing of conventional and modified-bituminous samples by the Marshall mix design and testing is done by Marshall stability test. Firstly, the tests related to materials-aggregates, bitumen, filler materials are done and the quality of each material is checked as per recommendations of code. Generally, the plastic is added into mix in two ways, wet mix and dry mix. In wet mix, the shredded plastic fibers are added directly into the hot bitumen and mixed with hot aggregates and laid on the ground. In dry mix, the aggregates are heated to a temperature of 165-175 degree Celsius and then this shredded plastic is added and mixed with hot bitumen and is laid on the ground. Generally dry mix is the most preferred one as compare to wet mix. so we follow dry mix. The plastic which is coated around the aggregates doesn't allow the water to flow through the aggregates which gives the durability, high stability value and high stripping value. The dry process is more preferred because the results which we got related to strength and durability criteria are more. So, we adopt dry process. Then this mix is made for testing with Marshall Stability test. Place the polymer-modified bitumen into the moulds. For comparison we have to make 3 trials on 3 different specimens of conventional bitumen(0% plastic), polymer-modified bitumen(5% plastic), polymer-modified bitumen(7% plastic) and polymer-modified bitumen(10% plastic). So, totally we have to make 12 moulds of two different bituminous mixes as mentioned above.



Fig.2: Aggregates and plastic materials used



Fig.3: Types of plastic to be used

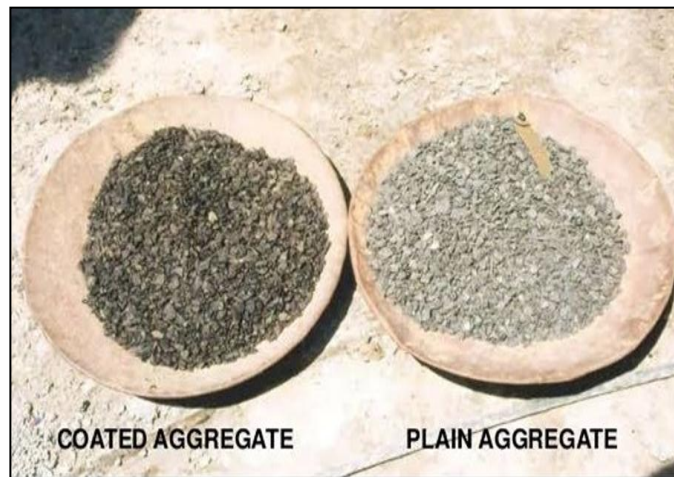


Fig.4: Plastic coated aggregates and plain aggregate



Fig. 5: Materials



Fig.6: heating of mix



Fig.7 &8: Marshall Stability Specimen moulds



Fig 9: mould filled with bituminous mix



Fig 10: Marshall Stability machine

Table: Materials and their quality tests as per Indian Standards

S.NO	MATERIALNAME	SPECIFICATIONS	TEST ON MATERIALS
1.	Bitumen	Penetration grade-60/70, 80/100 Viscosity-VG-30	Penetration Test [1202-1978] Softening Point [1205-1978] Ductility Test[1208-1978]
2.	Aggregates	Size- 20mm, 10mm	Sieve analysis [IS 2386-part-1] Aggregate impact test[IS 2386 part-4]

			Aggregate crushing value test [IS 2386- part-4] Water absorption [IS 2386-part-3]
4	Plastic	Plastic passing through 4.75mm sieve and retained on 2.36mm sieve	Sieve analysis

RESULTS AND ANALYSIS

Table 1: Physical properties of bitumen as per IS 73-1992 [1]

S.NO	Description	Test results	Permissible limits	Test method
1.	Specific gravity of bitumen	1.05	0.99 (minimum)	IS 1202-1978
2.	Softening point of bitumen	52.3°C	47°C	IS 1202-1978
3	Flash point of bitumen	270	220	IS 1209-1978
4	Fire point of bitumen	305	270	IS 12091978
5	Bitumen penetration test	50mm	45mm	IS 1203-1978
6.	Ductility test	94cm	100cm	IS 1208-1978

Table: Aggregate test results

S.NO	Description	Test results	Permissible limits	Test method
1.	Aggregate impact value test	24.50	Max. 30%	IS 2386-part-2
2.	Specific gravity of aggregates (20mm)	2.63		IS 2386- part-3
3.	Specific gravity of aggregates (10mm)	2.56		IS 2386-part-3
4.	Specific gravity of aggregates (6mm)	2.5		IS 2386-part-3
5.	Specific gravity of aggregates (stone dust)	2.46		IS 2386-part-3
6.	Stripping value of aggregates	4.6%	5%	Physical appearance
7.	Water absorption	0.52	Max 2%	IS 2386 part-3

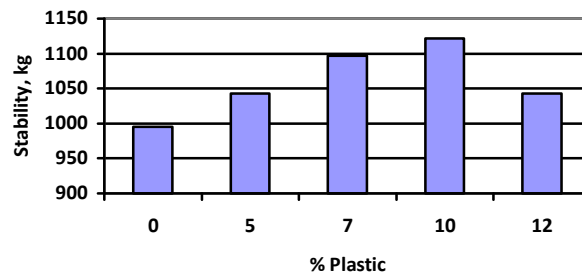
Stability vs Plastic content:

Table: Stability values with respect to % of plastic content

S. No	% Plastic Added	Avg. Stability Values Of 3 Specimens, kg
1	0	995
2	5	1043
3	7	1097
4	10	1122
5	12	1023

- From the above table it is clear that as % of plastic is increasing in the mix, the stability value increases.
- The optimum plastic content should be 10%.

Graph: Stability vs % plastic

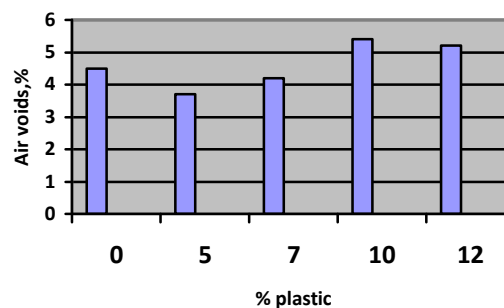


Air voids with respect to Plastic content:

Table: Air voids with respect to Plastic content

S.NO.	% plastic	Air voids, %
1	0	4.5
2	5	3.7
3	7	4.2
4	10	5.4
5	12	5.2

Graph: air voids vs % plastic



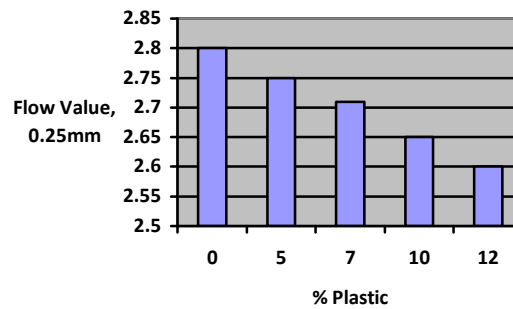
As per above graph, it is clear that the air voids increases with respect to plastic content because the plastic we added is attached around the rough surface of the aggregates. Due to this, the air voids are expecting to increase. This plastic layer decreases the flow of water between the aggregates will decreases.

Flow value vs % plastic

Table: Flow value vs % Plastic

S. No	% Plastic	Flow Value (0.25 mm)
1	0	2.8
2	5	2.75
3	7	2.71
4	10	2.65
5	12	2.60

Graph: flow value vs % plastic



CONCLUSION:

Bituminous plastic is used for the better performance of roads. This helps to have a better binding of bitumen waste plastic and aggregate due to increased bonding and increased area of contact between polymers and bitumen. The Plastic mix also reduces the voids. This prevents the moisture absorption and oxidation of bitumen by entrapped air. Results reducing rutting, raveling and there is no pothole formation. The roads can withstand heavy traffic and show better durability.

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