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EXPERIMENTAL STUDY ON PARTIAL REPALCEMENT OF BITUMEN BY POLYTHENE FOR V30 GRADE BITUMEN IN FLEXIBLE PAVEMENT

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ABSTRACT

The traffic pattern has changed since then and so has the technology. The volume of tandem, tridem and multi-axle vehicles has increased manifold and heavier axle loads are common. Since pavements are constructed as per the standards and specifications of design, which may not serve for the design period efficiently, safely, and economically due to early deterioration of materials with different properties. Now a days, the steady increment in high traffic intensity in terms of commercial vehicles, and the significant variation in daily and seasonal temperature put us in a demanding situation to think of some alternatives for the improvisation of the pavement characteristics and quality by applying some necessary modifications which shall satisfy both the strength as well as economical aspects. Also considering the environmental approach, due to excessive use of plastic in day to day business, the pollution to the environment is enormous. Since the plastic are not biodegradable, the need of the current hour is to use the waste plastic in some beneficial purposes. It is generally known that failure of asphalt pavement is due to fatigue cracking and rutting deformation, caused by excessive horizontal tensile strain at the bottom of the bituminous layer and vertical compressive strain on top of the subgrade. This presented study aim at expanding the scope of Plastic modified bitumen and the bitumen modified with waste plastic by with 3%, 5%, 6%, 7%. Plastic modified asphalt mix has 25% higher stability value compared to the conventional asphalt mix with a optimum dosage of 7%.

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I. INTRODUCTION

Plastic have become part of our today's lifestyle. It is used for packaging, for protecting, surveying purpose and discharging all types of goods with the industrial mass production of goods and plastics would be a cheaper and good constituent. Using of plastic non biodegradable (subjected to recent studies, plastic and stay for as long as 4200 years) product if growing speedily and its problem in disposal of plastic waste. Now a day, plastic wastes have been considered in pavement construction with great interest in develop countries such as Ethiopia and India. The use of material in road construction is totally based on economic, technical and ecological point of view also. Ethiopia has a large network of metro cities located in different parts of the country and many more are planned for future. Several metric tons plastic wastes are produced every year in Ethiopia. Keeping in mind that need for bulk use of these plastic wastes in Ethiopia develops specifications to enhance the use of these wastes in pavement construction, in which higher economic returns also possible. The use of these materials should be developed for construction of low-volume roads in different region of our country. The necessary specifications should be sort-out and attempts are to be made to maximize the use of plastic wastes in different layers of the road pavement construction. Many highway agencies are doing various studies on environmental suitability and performance of recycled products in high construction will help in disposal of vast quantities of plastic. Consumption of mineral water bottles which are made up of high density polyethylene has increased abnormally. These bottles are not readily biodegradable, environmental problems are created due to dumping; these are either land filled or incinerated which are not eco-friendly which pollute land and air. On heating at 100 – 150^0C, plastic such as polyethylene, polypropylene and polystyrene, soften and shows good binding properties. Blending plastic with a bitumen results in a mix that is amenable for road laying. These roads have withstood loads due to traffic, heavy rain and variation of temperature.

A. POLYETHANE

Plastic is material consisting of any of a wide range of synthetic or semi-synthetic organic compounds that are malleable and so can be molded into solid object. The success and dominance of plastic starting in the early 20^{th} century. The types of plastic are Low density polyethylene (LDPE), High density polyethylene (HDPE), Polypropylene (PP), Polystyrene (PS) and Poly vinyl chloride (PVC).

Plastics and municipal solid waste are great concern. Finding proper use for the disposal. Plastic waste is the need of the hour. On the other side, the road traffic also increasing, hence need to increase the load bearing capacities of the pavements. Due to increase in vehicles in recent years the road surfaces have been exposed to high traffic resulting in the deformation of pavements due to excessive stress. Pavement deformation happens when pavement does not have sufficient stability, improper compaction and insufficient pavement strength. The performance of pavement is determined by the properties of bitumen. Bitumen is a viscoelastic material with suitable mechanical and rheological properties for water proofing and protective covering for roofs and roads, because of its good adhesion properties of aggregates. One of the most important properties of bitumen mixture is its ability to resist shoving and rutting under traffic. Hence stability should be more enough to handle traffic adequately, but not more than the traffic criteria require. Low stability causes unraveling and flow of the road surface. Some improvements in asphalt properties have been achieved by selecting the proper starting crude, to make asphalt.

Use of polyethylene in road construction is not new. Some aggregates are highly hydrophilic (water loving). Like bitumen polyethylene is hydrophobic (water hating) in nature. So the addition of hydrophobic polymers by dry or wet mixing process to asphalt mix lead to improvement of strength, water repellent property of the mix. Polyethylene's get added to hot bitumen mixture and the mixture is laid on the road surface like a normal tar road. Plastic roads mainly use plastic carry-bags, disposable cups, polyethylene packets and PET bottles that are collected from garbage as important ingredients of the construction material. Polymer modification can be considered as one of the solution to improvise the fatigue life, reduce the rutting & thermal cracking in the pavement. Creating a modified bituminous mixture by using recycled polymers (e.g., polyethylene) which enhances properties of HMA mixtures would not only produce a more durable pavement, but also provide a beneficial way of disposal of a large amount of recycled plastics.

II. REVIEW OF LITERATURE

Amit Gawande (2012) - The quantum of plastic waste in municipal solid waste (MSW) is increasing due to increase in population, urbanization, development activities and changes in life style which leading widespread littering on the landscape. Thus disposal of waste plastic is a

menace and become a serious problem globally due to their non-biodegradability and un aesthetic view. Since these are not disposed scientifically &possibility to create ground and water pollution. This waste plastic partially replaced the conventional material to improve desired mechanical characteristics for particular road mix. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement11. This waste plastic modified bitumen mix show better binding property, stability, density and more resistant to water.

Sunil J. Kulkarni (2015) - Minimization of waste material is important aspect of the modern growth and development initiatives4. Plastic is used in various domestic and industrial applications. Use of plastic bags and bottles is very common. The disposal of plastic waste is major problem due to non-biodegradable nature of plastic. The plastic can be used as feedstock for ethanol like products. It can be used for road construction and other construction related activities. The current review summarizes the research on use of waste plastic

Rishi Singh Chhabra (2014) - In the highway infrastructure, a large number of originates material sand technologies have been invented to determine their suitability for the design, construction and maintenance of these pavements. Plastics and rubbers are one of them. Also considering the environmental approach, due to excessive use of polythene in day to day business, the pollution to the environment is enormous. The use of plastic materials such as carry bags, cups, etc. is constantly increasing day by day10. Since the polythene are not biodegradable, the need of the current hour is to use the waste polythene in some beneficial purposes. The use of these materials as a road construction proves eco-friendly, economical and use of plastic gives strength in the sub-base course of the pavement.

III. OBJECTIVES

The main objective of this experimental investigation is to provide tools to evaluate and to improve the properties of pavement using waste plastic such that it may be more confidently employed in roadways and driveways etc.

- To study on polymer modified asphalt mixture to evaluate engineering properties using marshal stability.
- To study basic properties of aggregates and plain bitumen.
- To study the strength and stability characters of BC mix for 80/100 grade bitumen.

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- To study the effect of waste plastic on strength and stability characteristics of BC mix.
- To study characteristics of bitumen.
- Study on performance of stability characters of BC mix.
- To study strength characteristics of waste plastics.
- Strength characteristics of BC mix.

IV. METHODOLOGY

i. Collect the waste plastic and shredding into small pieces.

ii. Finding out the bitumen properties for bitumen modified with waste plastic. The tests are penetration, softening point, ductility, specific gravity tests.

iii. Finding out the optimum plastic content by using Marshall Stability test. For this test prepared bituminous mix samples.

iv. Analyze the test results and findout the optimum dosage of plastic replacing as bitumen in the flexible pavement construction.

V. RESULTS

A. Bitumen properties by adding waste plastic

The bitumen replacing with waste plastic by 3%, 5%, 6% an 7%. Weighted the plastic as per the dosage and melted along with bitumen and findout the bitumen properties such as penetration, softening point, ductility and specific gravity. The test results mentioned below.

Table.1: Penetration test results

Name of the test	SPECIFICATION	RESULT	GUIDELINE FOLLOWED
Penetration test	Pure bitumen	72 mm	IS 1203:1978
	3%of polythene	48 MM	
	5%of polythene	46 MM	
	6%of polythene	45 MM	
	7%of polythene	25 MM	

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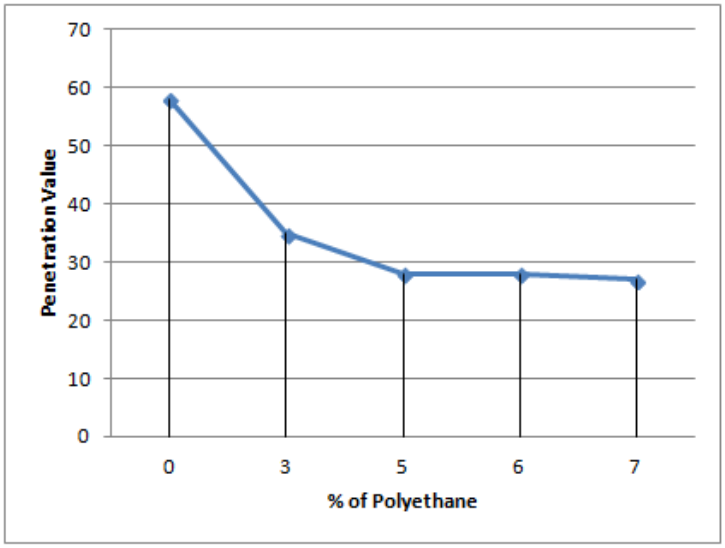

Graph: 1 Penetration Test Value

The penetration values were decreasing with increasing plastic as replacing in the bitumen. If the penetration values decreases the bitumen going to be harder.

Table.2: Softening point test results

Name of the test	specification	Result	Guideline Followed
Softening point test	Bitumen	55.5	IS 1205:1978
	3%of polythene	54.1	
	5%of polythene	61.25	
	6%og polythene	66.95	
	7%of polythene	67.84	

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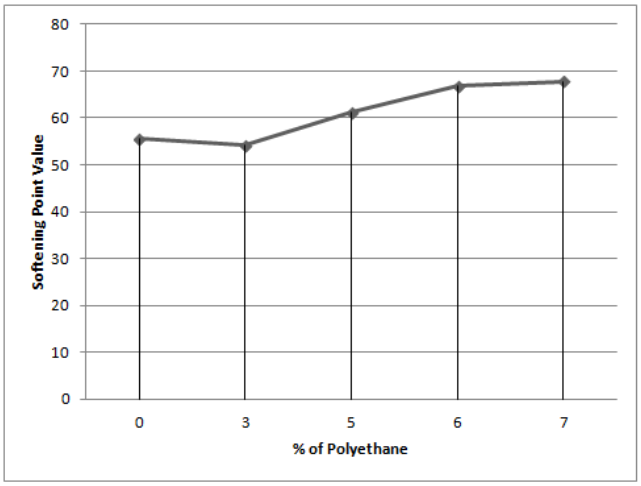
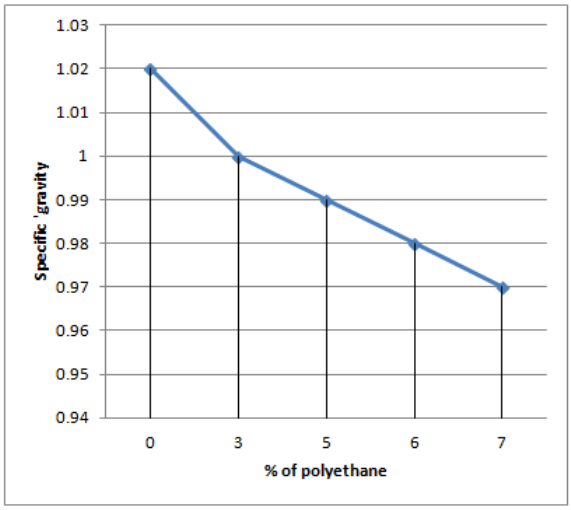


Graph :2 Softening point Test Value

The Softening values were increasing with increasing plastic as replacing in the bitumen. If the softening values increases the bitumen going to be harder.

Table.3: Specific gravity test results

Name of the test	Specifications	Result	Guideline followed
Specific gravity	Pure bitumen	1.02	ASTM D-2041
	3% of polythene	1.00	
	5% of polythene	0.99	
	6% of polythene	0.98	
	7% of polythene	0.97	



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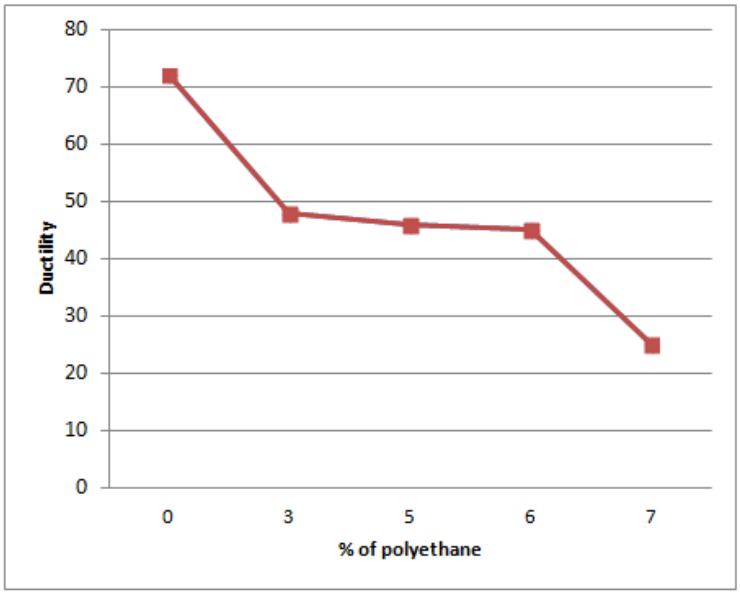
Graph :3 Specific gravity Test Value

The specific gravity values were decreasing with increasing the plastic replacement in the bitumen.

Table.4: Ductility test results

Name of the test	Details of sample	Result	Guideline Followed
Ductility test	Pure bitumen	75cm	IS 1208-1978
	3%of polythene	48	
	5%of polythene	46	
	6%of polythene	45	
	7%of polythene	25	



Graph :4 Ductility Test Value

The ductility values were decreasing with increasing plastic as replacing in the bitumen. The decreasing ductility values indicates the low in elongation properties.

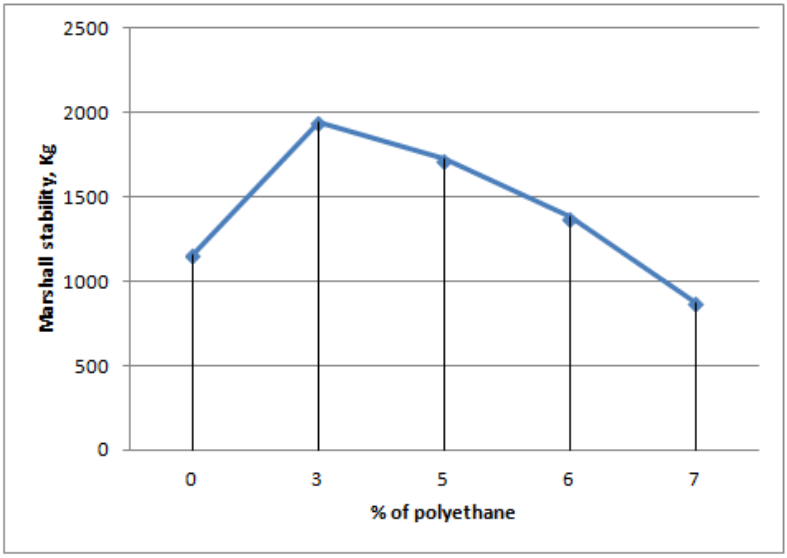
B. Marshall stability test

For finding the stability of bituminous mix using the test is Marshal Stability. The bitumen

replacing with waste plastic by 3%, 5%, 6% an 7%. Weighted the plastic as per the dosage and melted along with bitumen. The prepared modified mix, mixed with filler, fine and coarse aggregate as per the MORTH gradation. Heated and prepared bituminous mix compacted in the mould by 75times each side and cools it for 24hours in the room temperature. The Cooled sampled tested under Marshall Stability testing machine. The test results mentioned below.

Table.5: Marshall Stability test result

Name of the test	Specifications	Stability (Kg)	Flow (mm)	Guideline followed
Marshall stability	Pure bitumen	1160	6.1	ASTM D-1559
	3% Of polythene	1940.5	5.8	
	5% Of polythene	1724	5.4	
	6% Of polythene	1379	5.2	
	7% Of polythene	877	4.9	



Graph 5: Marshall Stability test result

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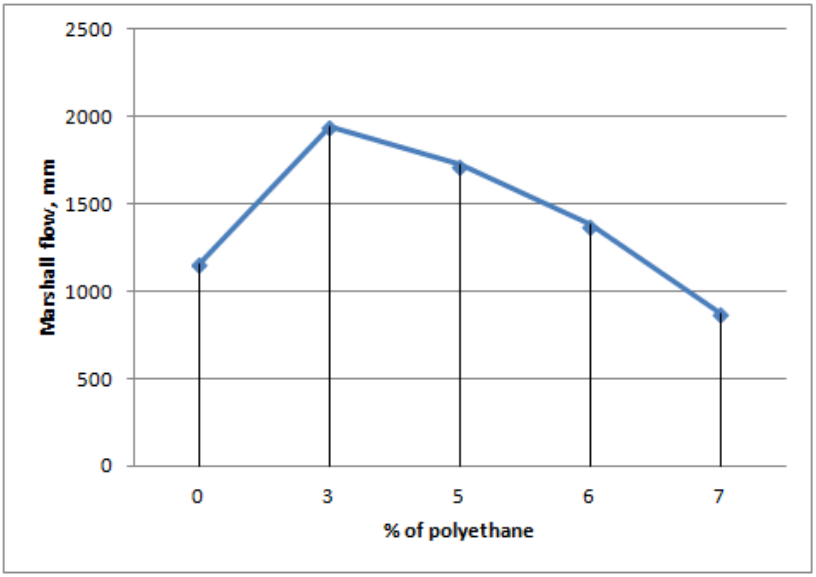

Graph 6: Marshall flow test result

VI. CONCLUSIONS

The plastic mixed with bitumen and aggregates is used for the better performance of the roads. The polymer coated on aggregates reduces the voids and moisture absorption. This result in the reduction of ruts and there is no pothole formation. The plastic pavement can withstand heavy traffic and are durable than flexible pavement. The use of plastic mix will reduce the bitumen content by 7% and increases the strength and performance of the road. This new technology is eco-friendly. The use of smoke absorbent material (titanium-dioxide) by 7% of polymer content can reduce the vehicular pollution.

Stability : Plastic modified asphalt mix has 25% higher stability value compared to the conventional asphalt mix. The improvement of stability in plastic modified asphalt mixes can be explained as a result of the better adhesion developed between bitumen, plastics and aggregates due to intermolecular bonding, these intermolecular attractions enhanced strength of asphalt mix, which in turn help to enhance durability and stability of the asphalt mix. The flow was decreased with increased percentage of replacing bitumen with waste plastic.

Cost Reduction : Plastic modified asphalt mix has 10.06% lower in cost than the conventional asphalt mix.

Optimum Plastic Content : The optimum amount of waste plastic to be added as a modifier of asphalt mix was found 11.5 % by weight of optimum bitumen content. And the optimum bitumen content found for marshal mix was 4.8%.

Softening Point : The temperature resistance of plastic modified asphalt is higher than the conventional asphalt (63.55ºc>55.55ºc) due to the rigid property of plastic.

Plastic Management : Due to plastics are utilized within bituminous mixes as road construction materials, environmental pollution caused by plastics is solved.

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